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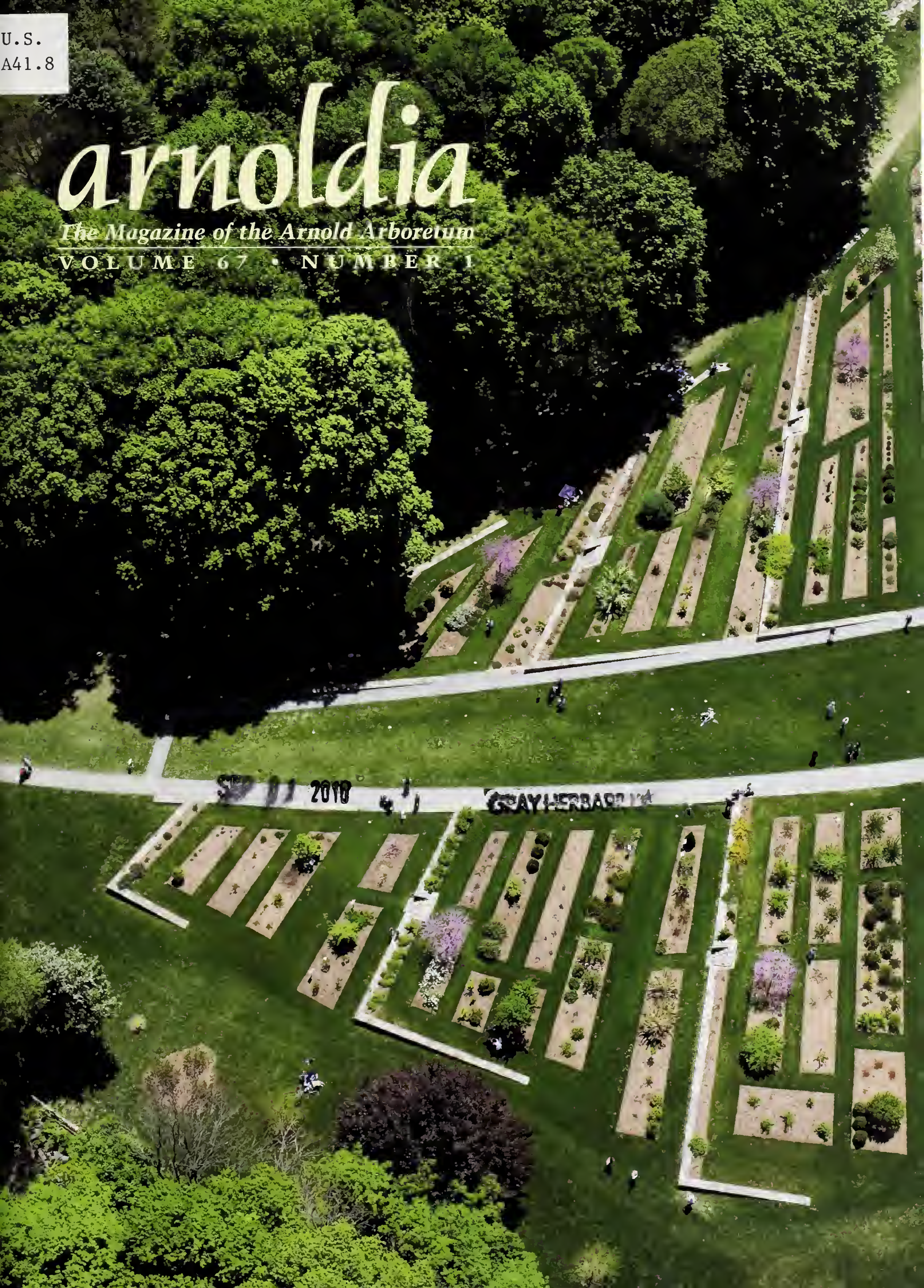
The Magazine of the Arnold Arboretum

VOLUME 67 • NUMBER 1



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The ARNOLD ARBORETUM of HARVARD UNIVERSITY

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Front cover: Aerial photography has provided fascinating views of the Arnold Arboretum over many years, as evidenced in Sheila Connor's article. Here, the Leventritt Shrub and Vine Garden is seen from the air in May, 2005. Photo by Jay Connor.

Inside front cover: A close-up showing the lacy inflorescences of this issue's profiled plant, *Hydrangea paniculata* 'Praecox'. Photo by John H. Alexander III.

Inside back cover: Curatorial Fellow Sue A. Pfeiffer describes the history and ornamental features of the Arnold Arboretum introduction *Hydrangea paniculata* 'Praecox', seen in photographs from about 1930 (upper left; Arnold Arboretum Archives), 1988 (upper right; John H. Alexander III), and about 1996 (lower; Peter Del Tredici).

Back cover: Though not well known today, quince was once an important orchard fruit. This 1909 botanical illustration of 'Champion' quince by Amanda A. Newton is one of a series of detailed pomological watercolors commissioned by the USDA in the late nineteenth and early twentieth centuries. The collection is now housed at the National Agricultural Library in Beltsville, Maryland.

Cydonia oblonga: The Unappreciated Quince

Joseph Postman

The quince of Persia attains a weight of 1.5 kilos (more than 3 pounds), ripens on the tree or in the store, and can be eaten like a soft ripe pear, according to a report in *The Horticulturist, and Journal of Rural Art and Rural Taste* of 1849 (Meech 1908).

That description hardly fits the quince known in America today, or rather the quince which is hardly known today. During Colonial times a quince tree was a rarity in the gardens of wealthy Americans, but was found in nearly every middle class homestead (Roach 1985). The fruit—always cooked—was an important source of pectin for food preservation, and a fragrant addition to jams, juices, pies, and candies. However, by the early twentieth century quince production declined as the value of apples and pears increased. Today's consumers prefer the immediate gratification provided by sweet, ready-to-eat fruits. After Charles Knox introduced powdered gelatin in the 1890s the use of quince pectin for making jams and jellies declined. U.P. Hedrick lamented in 1922 that "the quince, the 'Golden Apple' of the ancients, once dedicated to deities and looked upon as the emblem of love and happiness, for centuries the favorite pome, is now neglected and the least esteemed of commonly cultivated tree fruits." (Hedrick 1922)

Luther Burbank took credit for transforming this neglected fruit from a commodity that was "altogether inedible before cooking" into a crop he likened to the best apple. He half-jokingly cited a formula to make quince fruits edible prior to his breeding efforts: "Take one quince, one barrel of sugar, and sufficient water..." (Whitson et al. 1914). Burbank released several improved cultivars in the 1890s that he hoped would raise the status of the fruit. Two Burbank cultivars, 'Van Deman' and 'Pineapple', are important commercially in California today, but overall quince fruit production in the United States is so small that it is not even tracked by the USDA National Agricultural Statistics Service (McCabe 1996; USDA 2009b). While underappreciated here, these Burbank quinces have found their way to other parts of the world where they are among the handful of cultivars considered worthy of production (Campbell 2008).

Burbank's 'Pineapple' quince as seen in a photograph from the 1914 multi-volume publication *Luther Burbank, His Methods and Discoveries and Their Practical Application.*

In 1908, Meech described 12 quince varieties important in the United States at the time, although some

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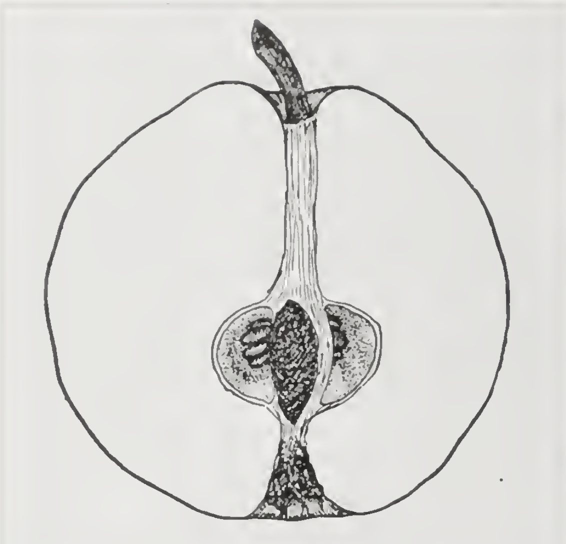
The attractive flowers and foliage of quince.

like 'Orange' (syn. = 'Apple') were as often as not grown from seed rather than propagated as clones. Quince is easily grown from either hardwood or softwood cuttings, and is readily grafted onto another quince rootstock. Although it is an important dwarfing rootstock for pear, quince should not be grafted onto pear roots because this reverse graft is not reliable.

Quince has a very extensive history in the Middle East, and may have even been the fruit of temptation in the story of the Garden of Eden. The ancient Biblical name for quince translates as "Golden Apple" and cultivation of *Cydonia* predates cultivation of *Malus* (apple) in the region once known as Mesopotamia, now Iraq. Juniper and Mabberly (2006) explain how this region is well adapted to cultivation of quince, pomegranate, and other fruits, but Mesopotamia was much too hot and dry for the cultivation of all but the most recently developed low-chilling-requirement apples. Quince was revered in ancient Greece, where a fruit was presented to brides on their wedding day as a symbol of fertility. It was mentioned as an important garden plant in Homer's *Odyssey*, and Pliny the Elder extolled its medicinal properties.

Botany and Intergeneric Liaisons

Cydonia oblonga is a monotypic genus belonging to family Rosaceae, subfamily Spiraeoideae, tribe Pyreae, and subtribe Pyrinae (USDA 2009a). It grows as a multi-stemmed shrub or small tree and has pubescent to tomentose buds, petioles, leaves, and fruit. Leaves are ovate to oblong, about 2 inches (5 centimeters) across and 4 inches (10 centimeters) long. The solitary white flowers are 1½ to 2 inches (4 to 5 centimeters) across, have 5 petals, 20 or more stamens, 5 styles, an inferior ovary with many ovules, and are borne on current season growth. Bloom time overlaps with that of apples, usually beginning mid April in the central latitudes of the northern hemisphere. The fruit is a fragrant, many-seeded pome about 3 inches (8 centimeters) in diameter. Shape ranges from round to pear-like, flesh is yellow, and the Baileys refer to it as "hard and rather unpalatable"



103. Orange. (×½)

Illustration of 'Orange' quince from U.P. Hedrick's 1922 *Cyclopedia of Hardy Fruits*.

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A *Pyronia* fruit—from a cross of *Pyrus pyrifolia* (Japanese pear) and *Cydonia oblonga*—growing in the USDA genebank orchard.

(Bailey and Bailey 1976; Rehder 1986). Fruit size and leaf size of cultivated varieties can be many times larger than the wild type described above. All varieties are self-pollinating.

Intergeneric crossing is fairly rare in plants, but has occurred naturally on occasion in the Rosaceae. While not as promiscuous as its cousins *Sorbus* and *Mespilus*, *Cydonia* has had a number of encounters with related genera that resulted in intergeneric offspring. In 1913 a Mr. Veitch in London sent scions of a quince-pear hybrid to Louis Trabut, the Algerian botanist. Trabut proposed the name *Pyronia veitchii* for this curious seedless-fruited hybrid (Trabut 1916). *Pyronia* is little known today, except by fruit tree pathologists who use the virus-sensitive clone as a graft-inoculated indicator to detect virus diseases in pome fruits. Another more recent hybrid generated in Japan between *Cydonia* and the Japanese pear, *Pyrus pyrifolia*, was probably the product of embryo rescue, a controlled tissue culture technique. In Italy and the Czech Republic, a purported hybrid between quince and apple (*Cydomalus*) has been touted as a possible rootstock for both apples and pears (Wertheim 2002).

Center of Origin

Cydonia is native to western Asia, and the center of origin is considered to be the Trans-Caucasus region including Armenia, Azerbaijan, Iran, southwestern Russia, and Turkmenistan (USDA 2009a). During ancient times, quince spread from its wild center of origin to the countries bordering the Himalaya Mountains to the east, and throughout Europe to the west. It has many uses and traditions associated with it throughout this broad range. Several recent USDA funded plant collecting expeditions to Armenia, Georgia, and Azerbaijan returned with quince seeds and cuttings from these countries. The availability of *Cydonia* germplasm in the United States increased significantly from 2002 to 2006 as a result of these collections (McGinnis 2007).

Cultivation for Fruit and Rootstock Production

Worldwide, there are about 106,000 acres (43,000 hectares) of quince in production with a total crop of 335,000 metric tons. Turkey is the largest producer with about 25% of world production. China, Iran, Argentina, and Morocco each produce less than 10%. The United States is a very minor player in quince fruit production with only about 250 acres (about 100 hectares) planted, mainly in California's San Joaquin Valley. Burbank's 'Pineapple' is the most widely grown cultivar in that state and is said to be more flavorful than 'Smyrna' (McCabe 1996).

Quince fruit has a number of culinary uses. *Dulce de membrillo*, or quince paste, is popular in several European countries, particularly Spain. It is also much appreciated in parts of

JOSEPH POSTMAN

Dr. Vagharshak Hayrapetyan, head of the Scientific Center for Viticulture, Fruit Growing, and Winemaking in Yerevan, Armenia, poses with the winter quince variety 'Chartar Gyugh' in September, 2006. Scions of this heirloom quince cultivar were recently brought to the United States.

Latin America. This sweet, fragrant, jellylike confection is cut into slices and often served with a heady cheese. Quince is also served poached in either water or wine, and when so prepared develops a rich aroma and deep caramel-red color. In Armenia, quince is used in many savory as well as sweet dishes, and is often cooked with lamb (Ghazarian 2009). Quince fruit is also used by some home brewers to make very fine hard ciders.

While quince is still grown for its fruit in some parts of the world, in England, France, and the United States it is primarily grown for use as a dwarfing pear rootstock. In the region around Angers, France, quince has been used as a pear rootstock since before 1500. The French were growing quince plants from cuttings and layering in stool beds by the early 1600s and France became an important source of rootstocks around the world. Quince rootstocks grown near Angers were known as 'Angers Quince' and those propagated near Fontenay were known as 'Fontenay Quince' (Roach 1985; Tukey 1964). Confusion arose about the identities of various quince rootstocks, and in the early 1900s researchers at East Malling in England collected rootstocks from a number of nurseries and designated clones with letters of the alphabet. Quince rootstock clones now available in the United States include Quince A and Quince C, which came from East Malling–Long Ashton (EMLA); and Provence Quince (= Quince BA 29-C) from France. A pear tree grafted onto Quince A will be about half the size of a tree grafted onto pear seedling rootstock. The tree will also be more precocious and fruit size will be larger. Quince C produces a tree slightly smaller and more precocious still. Provence Quince rootstock produces a pear tree slightly larger than Quince A or C. Some pear varieties are not graft compatible with quince and require a compatible interstem pear variety such as 'Comice', 'Old Home', or 'Beurre Hardy' as a bridge.

Landscape Use

Few small trees rival the quince in becoming interestingly gnarled and twisted with age. Nonetheless, renowned Arnold Arboretum horticulturist Donald Wyman (Wyman 1965)

STEPHEN AUSMUS, USDA ARS

These bowls of quince show the diversity of shapes found in quince fruit.

JOSEPH POSTMAN

This young quince tree, growing in the genebank orchard at USDA-ARS, Corvallis, Oregon, has been pruned to open up the crown and remove basal suckers.

did not consider *Cydonia* worthy of his list of recommended landscape trees. He relegated it to his secondary list because of inferior flower interest, poor growth habit, and pest problems. However, *Cydonia* is an essential component of many historic gardens, and Frederick Law Olmsted included the common quince as a valuable plant in some of his landscapes (Deitz 1995).

As a young tree, *Cydonia* may sucker profusely, and it takes some pruning effort during the first few years to establish an open-crowned specimen tree rather than a small thicket. Quince is such an interesting plant that it's worth the pruning effort, and germplasm recently imported from other parts of the world may provide some relief from pest and climate challenges that limited its use in the past.

Potential for Genetic Improvement

Quince is adapted to hot, dry climates and to acid soils. Under favorable conditions, ripe fruit can become quite fragrant, juicy, and flavorful. When grown in high pH soils, however, trees can become stunted and suffer iron chlorosis. In northern latitudes or colder climates the fruit of many cultivars does not fully ripen prior to the onset of winter, and in places where it rains during the ripening season, fruit cracking can be a big problem. Although most commercial quince production today is located in very warm areas, one of the largest quince orchards in 1895 was a 60 acre (24 hectare) planting in upstate New York near Waterport (Brown's Berry Patch 2007).

Whether grown for fruit production or for use as a pear rootstock, quince is impacted by several disease problems. Fire blight caused by the bacterium *Erwinia amylovora* limits the cultivation of quince either for its fruit or as a pear rootstock, especially in regions with warm, humid summers. The genus *Cydonia* is one of the most susceptible to fire blight in Rosaceae, the plant family which includes many susceptible hosts (Postman 2008). Leaf and fruit spot caused by *Fabraea maculata* (anamorph = *Entomosporium mespili*) can result in tree defoliation and production of disfigured, unmarketable fruit if not controlled. Powdery mildew and rust diseases also impact quince production.

Genetic improvements needed for expanding the use of quince as a dwarfing pear rootstock include increased resistance to fire blight for warm and humid summer climates, and increased winter cold-hardiness for northern climates. Adaptation to alkaline soils will allow quince production to expand to more diverse

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The Turkish cultivar 'Harron' has the largest fruit size of the hundred or so quince clones growing at the USDA genebank, but the fruit may crack badly when exposed to rain just before it is ripe.

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A young boy in Georgia's northeast province of Kakheti displays quince fruit from a tree in the village of Shilda. Scions of the Shilda quince were collected by ARS genebank curators Joseph Postman and Ed Stover during a 2006 expedition to the Caucasus region. A tree is growing in quarantine at Beltsville, Maryland, and will be sent to the USDA-ARS genebank in Oregon upon release

soil conditions both as a rootstock for pear or for production of quince fruit. Very slight progress in soil adaptation was achieved by selecting somoclonal variants of rootstock clone Quince A following multiple generations of in vitro culture on high pH media (Bunnag et al. 1996). Quince for fruit production will benefit from earlier ripening, and elimination of summer "rat-tail" blooms, which predispose a tree to attack by fire blight. Fruits that are picked too green will never ripen properly (McCabe 1996). Resistance to the fungal rusts and mildews will allow quince to be produced with fewer pesticide applications.

Available Germplasm

A quince germplasm collection was established in Izmir, Turkey, beginning in 1964 that includes many regionally developed fruit cultivars and landraces (Sykes 1972). In Karaj, Iran, a collection of more than 50 *Cydonia* accessions are maintained, including both cultivated and wild types (Amiri 2008). Smaller quince collections are growing in Italy, Greece, Spain, and other European countries (Bellini and Giordani 1999). There are also significant collections in Ukraine and southwest Russia. A large fruit tree collection in Kara Kala, Turkmenistan, was once a part of the Vavilov Institutes during Soviet times. Many fruit tree accessions, including quince, were rescued from that station in the late 1990s and brought to other genebanks for safekeeping.

More than a dozen quince accessions from Kara Kala, representing both wild types and fruiting cultivars, are growing at the USDA genebank in Oregon. The Oregon facility is one of several ex situ genebanks housing temperate fruit and nut collections for the USDA National Plant Germplasm System (NPGS) (Postman et al. 2006). The NPGS *Cydonia* collection includes more than 100 clones with origins from 15 countries maintained as self-rooted trees in a field collection (Postman 2008). About half of this collection represents cultivars for fruit production, and the other half are pear rootstock selections, wild types, and seedlings. Observations made at the genebank have revealed a wide diversity of genotypes, some with resistance to *Fabraea* leaf and fruit spot, and a range of ripening seasons that may make it possible to produce quince fruit in short-season production areas. Quince selections made in Bulgaria following a fire blight epidemic in that country have shown good field resistance to the disease, and some of this Bulgarian germplasm was recently introduced into the United States by the NPGS genebank.

For nearly a century, the quince has been almost ignored for fruit production in North America, while many improvements have been made in the Middle East and central Asia. Germplasm is now available in the United States for expanding the use of *Cydonia* both as a rootstock for pear and as a fruit producing tree in its own right. As Luther Burbank concluded a hundred years ago, "The quince of today is, indeed, a half wild product that has waited long for its opportunity. It remains for the fruit growers of tomorrow ... to see that the possibilities of this unique fruit are realized" (Wickson et al. 1914).

The Chinese Quince: *Pseudocydonia sinensis*

This Chinese relative of *Cydonia* presently belongs to the genus *Pseudocydonia*, but has previously been assigned to both *Chaenomeles* (*Chaenomeles sinensis*) and *Cydonia* (*Cydonia sinensis*). Chinese quince has attractive single pink flowers that appear earlier than those of *Cydonia* but not as early as most *Chaenomeles*. The fruit is a large, oval, aromatic yellow pome that ripens in the fall. The shiny, leathery leaves develop nice red-orange fall color. But its most interesting characteristic is the exfoliating bark that reveals brown, green, orange, and gray patches. Chinese quince's attractive bark rivals that of many stewartias. The trunk often becomes fluted with age, adding even more textural appeal.

MICHAEL DOSMANN

Luther Burbank devoted some attention to the Asian quinces and was probably responsible for a large-fruited clone of *Pseudocydonia*. Michael Dirr (1997) notes that Chinese quince is reliably hardy in USDA Zones 6 to 7 (average annual minimum temperatures -10 to 10°F [-23 to -12°C]), and possibly hardy in Zone 5 (-20 to -10°F [-29 to -23°C]). Fire blight is said to seriously impact its cultivation. However, the presence of very nice specimens of Chinese quince at the National Arboretum in Washington, D.C., and in gardens in the Carolinas—locations where *Cydonia* is readily killed by fire blight—indicate that it can be grown even in regions where the disease is present.

COURTESY OF KEN PEI

Chinese quince's pink flowers, attractive patchwork bark, and fluted trunk are highly ornamental.

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Information about quince genetic resources in the USDA National Plant Germplasm System, as well as a field day on October 10, 2009 featuring the Corvallis genebank's quince orchard, is available at http://www.ars.usda.gov/pwa/corvallis/ncgr. A one day symposium on underutilized pome fruits will be held in August, 2010 during the 28th International Horticulture Conference in Lisboa, Portugal. For more information visit the 'Symposia' link at http://www.ihc2010.org/

Bird's-eye Views: Aerial Photographs of the Arnold Arboretum

Sheila Connor

Our desire to fly must have been driven, in part, by wanting to have a bird's-eye view of the land. Today, we can launch ourselves skyward simply by clicking on Google Earth, where a virtual world created by combining aerial photography, satellite imagery, and GIS (geographic information systems) unfolds on our computer screen.

Attainment of that instant bird's-eye view was many years in the making, though. The first aerial photographs were taken from a hot air balloon in 1858 by the French portraitist "Nadar" (Gaspard-Félix Tournachon), who did so while tethered 240 feet (73 meters) above the village of Petit-Bicêtre near Paris. Two years later—also in a tethered hot air ballon—James Wallace Black ascended 1,200 feet (366 meters) over the densely developed port city of Boston, Massachusetts. His image, "Boston, as the eagle and wild goose see it," is the earliest known aerial photograph still in existence. Kites, rockets, and carrier pigeons (outfitted with tiny breast-mounted cameras) were the next airborne means used.

James W. Black's 1860 image of Boston, the earliest aerial photo still in existence.

Just a few years after the Wright brothers famous first flight, images were shot from an airplane piloted by Wilbur Wright, the first taken from an airplane. The military, both here and abroad, quickly grasped the value of these unexpectedly revealing views and established aerial reconnaissance units. Following World War I, newly created commercial companies expanded upon the progress made in aerial techniques.

New Equipment, New Techniques

Sherman Mills Fairchild started several of these new peacetime ventures. Fairchild had originally secured a contract with the army to develop a camera for aerial photography. With the shutter placed inside the lens, his high-speed camera was capable of producing images with little or no distortion, which made accurate mapping possible. Although the army did not take delivery of his cameras until after the war, Fairchild continued to improve upon his design and, in 1920, started the Fairchild Aerial Camera Corporation.

He also began designing aircraft to suit his photographic needs and founded his second company, Fairchild Aerial Surveys, Inc. The company is well known for the remarkable aerials it produced of every major city in the United States between 1920 and 1960, and the Arboretum was one of its earliest clients. Using one of the company's specially designed cameras, a pilot flew over the Arboretum in 1927 in a Fairchild FC-1 and took "the first airplane view to show all of America's greatest hardy garden," as reported in the *Boston Herald* newspaper. This "bird's-eye view" was

ALL PHOTOS FROM THE ARCHIVES OF THE ARNOLD ARBORETUM UNLESS OTHERWISE INDICATED

This 1927 Fairchild aerial photograph of the Arboretum, looking toward Boston, shows Peters Hill in the foreground and the familiar curlicue of roadway atop Bussey Hill.

JAY CONNOR

This 2005 image was made with the same perspective as the 1927 photo. Peters Hill is in the foreground, but mature trees now obscure the top of Bussey Hill. Downtown Boston is seen in the distance.

A large paved circle for bus turnarounds is seen atop Peters Hill in this 1967 photograph. Prior to 1964 there was no paved roadway to the top of the hill. In the late 1990s the paving was removed as part of a landscape restoration project that returned the hilltop to a design consistent with Frederick Law Olmsted's naturalistic style.

JAY CONNOR

Additional unplanned footpaths created over the years are visible in this 2007 image of Peters Hill. In place of the pavement at the summit there are now a scattering of granite blocks used for informal seating. The granite blocks, recycled from a demolished Olmsted-era bridge that once stood near the Forest Hills Station, were originally placed in a circle on Peters Hill in the 1980s to deter a then popular youth activity—setting stolen cars on fire and pushing them down the hill.

reproduced in the the newspaper's autogravure section on November 20, 1927.

Since that initial flight, photographers have used planes, helicopters, a dirigible, and, most recently, a drone as means to attain views of the Arboretum. The resulting collection of negatives, microfiche, prints (both black and white and color), and digital images provides a unique perspective and an amazing record of how change occurs in the Arboretum's seemingly permanent landscape. Entire plant collections disappear only to reappear years later completely redesigned and reconfigured. Others simply disappear. A few migrate, acquire a new name, then eventually vanish. Roads appear, are paved, then unpaved, and fade away. Sidewalks and paths (whether planned or established by desire) do the same, and while our aerial archaeology has not revealed any crop circles, one can easily see the remains of the characteristic circles that signify abandoned planting holes, sites where specimens once grew.

Making Maps

The first vertically shot aerial survey of the living collections took place in 1936. (In vertical aerial photography the camera is in a level position and pointing directly downward, the best format for precise mapping.) This survey consisted of a series of four images taken by Bradford Washburn, then a 26-year-old instructor at Harvard's Institute for Geographical Exploration. His long

When seen from above in this 1955 Bradford Washburn aerial (top), the broad, grassy plain just below the summit of Bussey Hill sports shadows of planting holes from the *Prunus* collection that once occupied the site, seen in the May 1929 photo (bottom) taken by the renowned New England landscape photographer Herbert Wendell Gleason.

affiliation with the Arboretum, coupled with his expertise in aerial photography and cartography, greatly influenced the number of aerial photographs taken of our landscape.

Mr. Washburn often acted as a project manager, directing and organizing both vertical and oblique (camera is angled) shots made of the arboretum. Under his direction an image of the

One of Washburn's 1936 vertically shot aerials of the Arboretum. Marked on the map are:

1. Present site of the Dana Greenhouse, constructed in 1962, and the Leventritt Pavilion and Shrub and Vine Garden (an aerial view of this garden is on the front cover).
2. The site of the original Shrub and Vine Collection, now occupied by the Bradley Rosaceous Collection.
3. Site of the Bussey Institution, the location of the Arboretum's greenhouses prior to 1962, and now the site of the Massachusetts State Laboratory.
4. Bussey Brook Meadow, also known as the South Street Tract and Stony Brook Marsh, prior to the pond being filled in and the creation of the Blackwell Footpath
5. Peters Hill had only the outer ring road at the time.
6. Weld Hill, once known as the Weld Walter Street Tract, prior to the construction of the Hebrew SeniorLife Center on the site of the former Joyce Kilmer Park
7. Highly visible remnant of Centre Street left from the Centre Street realignment and widening in 1931. Today, a grassy swath still indicates the route of the old roadbed.

entire Arboretum was taken in 1952. Then in 1955, his first year as chairman of the Arboretum's Visiting Committee, he raised the sum of $310.00 from the committee for a flyover by Eastern Aerial Surveys, Inc., with the recommendation that a second survey take place the following spring. Twelve images resulted from the October 6 survey. Unfortunately there is no record of a spring session. Northeast Aerial Photos produced the first series of color images of the Arboretum in 1967. A year later, color images of the Hunnewell Building and the newly built garage facility were taken, and in 1974 a survey of the entire Arboretum produced a suite of seventeen images.

The Hunnewell Building and then newly built garage behind it are shown in this 1968 photograph.

JAY CONNOR

A similar view as seen in May, 2005.

Bradford Washburn's long-held goal of creating a mapping system of the Arboretum's living collection based on aerial photography finally came to fruition when Dr. Peter Shaw Ashton, then director of the Arboretum, approached him in 1978 to orchestrate the coordination of a photogrammetric survey of the Arboretum by Swissair Photos + Surveys, Ltd. (now named Swissphoto AG).

"On a cloudless day in April, 1979, the survey crew took a series of aerial photographs, which were then transformed into orthographically corrected images displaying an exceptionally accurate picture of the Arnold Arboretum at a scale of 100 feet to the inch. A ground-survey team was hired to complete the contours in certain areas of the Arboretum that are covered by an evergreen canopy. Swissair provided the Arboretum with a base map of the grounds that illustrates true north, contour lines at intervals of ten feet, physical features (roads, paths, walls, and buildings), and reference points."

From the article "Cartographic Records of the Living Collections" Ethan W. Johnson, *Arnoldia*. 49 (1) 1989.

BRADFORD WASHBURN was an extraordinary man. Born in Boston in 1910, as a teenager he developed a love for mountain climbing, summiting peaks around the world in the days well before high tech climbing gear was available. As an undergraduate at Harvard he honed his passions—climbing, photography, and scienctific exploration—and in 1934 pursued graduates studies in cartography, surveying, and aerial photography at Harvard's Institute for Geographical Exploration. At 29 he became the director of the New England Museum of Natural History, now the Boston Museum of Science, a position he held for 40 years. As a pioneer in aerial photography, Washburn's stunning mountain images made him one of the most important landscape photographers of the twentieth century. Recently, one of Washburn's cameras (a 1929 Zeiss 4 x 5) was taken on the space shuttle's Hubble telescope repair mission by astronaut and mountain climber John Grunsfeld. It seems fitting that Washburn's camera was used to make the ultimate in aerial photos—images from space.

***Bradford Washburn and the Fairchild 71 Monoplane, Valdez, Alaska*, a 1937 gelatin silver print photograph by Bob Reeve.**

Susan Kelley, then curatorial associate in mapping, and I met with Mr. Washburn in 2000 to learn more about his early Arboretum work. He believed that his photographs of the collections would eventually provide a valuable record. Upon seeing our current maps of the living collections, which were based on the 1979 photogrammetric survey and formatted in AutoCAD, which interacts with the computerized plant records database, BG-Base, Mr. Washburn pronounced them "gorgeous!"

More Bird's-eye Views

Sasaki Associates Ltd. produced aerials in 1990 and 1991 as part of the Arboretum's Master Plan process, and in 2002 the Arboretum participated for the first time in a survey of the Harvard campus, which was coordinated by Harvard's Planning and Real Estate Department. The living collections were again included in the Harvard survey in 2006. Recently, when aerial imagery has been needed, photographs have also been acquired from surveys done by the United States Geological Surveys (USGS). Our most recent full scale vertical aerial view of the entire Arboretum was taken in spring 2008, as part of the USGS Boston 133 Cities Urban Area mapping program.

Interspersed between these major surveys were other more site specific or overview flights. In 1950, Arboretum horticulturist Donald Wyman took a series of photographs at a

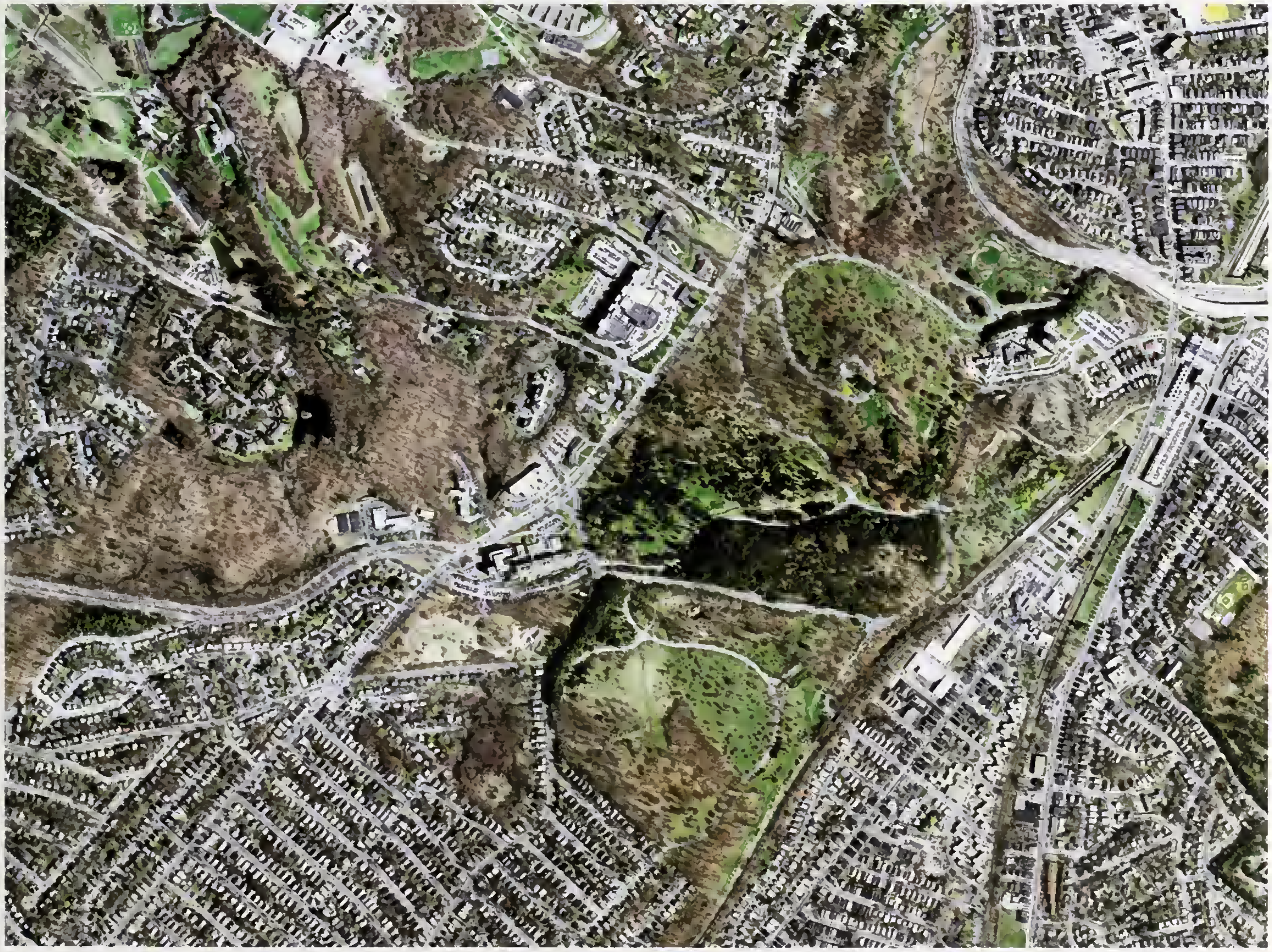

Image of the Arnold Arboretum in 2008 from the United States Geological Surveys.

Weld Hill in 1955, with Kilmer Park adjacent (top of photo).

Weld Hill in 2006, part of the Harvard survey.

height of 3,000 feet from a plane flown by his 17-year-old son.Wyman's photographs were taken from a vantage point reminiscent of the 1927 Fairchild survey images. Eight years later, Heman Howard, in charge of the mapping and labeling department, also duplicated this view with a series of oblique shots from both 1,400 and 2,300 feet. The Massachusetts Department of Public Works photographed the lilac collection and replicated the bird's-eye view in 1969 and, in 1995, Sergio Marino of GPI Models took a series of images from a helicopter to facilitate his construction of an 8 feet by 16 feet scale model of the Arboretum. The model became

FULLERVIEW PHOTOGRAPHY

An oblique view of Weld Hill, taken from a drone on May 20, 2009, shows the Arboretum's new research facility under construction.

the centerpiece for the exhibit *Science in the Pleasure Ground* in the Arboretum's Hunnewell Visitor Center, where it continues to be a popular feature. My brother, Jay Connor, has taken almost 200 oblique images of the collections. He began photographing the Arboretum in 2004, usually from a helicopter, but once from the iconic Hood Blimp, officially an American A-60+ Lightship. This familiar cigar-shaped balloon is capable of hovering motionless for hours at a time. As Boston Red Sox fans can attest, it is truly an airship designed for aerial observations.

The Arboretum's most recent aerial photography project involves the new research facility on Weld Hill. Over the past two years, Dave Fuller of Fullerview Photography has sent up a drone to capture images of the construction of the building. Over the coming months, arboretum staff will be adding aerial imagery to our GIS (geographic information system) using ESRI software. This will provide a new generation of bird's-eye views of the arboretum's landscape and its change over time. Incorporating these images into our GIS system will assist in reconciling diverse georeferenced features and provide unprecedented detail about our living collections for researchers and visitors.

Sheila Connor is the Horticultural Research Archivist at the Arnold Arboretum.

Seeking Cold-Hardy Camellias

Anthony S. Aiello

For those of us in more northern climates, trips to southern or West Coast gardens in early spring often result in admiration (and a little envy) for the range and beauty of camellias (*Camellia* spp.) that can be grown in Zones 7 or warmer. As with many plants, we always want those that are either too tender or too boreal for our zone; those plants well suited for a particular climate are all too quickly considered prosaic and it is the struggling arcane plants that most of us cherish as gardeners. It was the tantalizing possibility of finding more cold-hardy camellias that 25 years ago led to a plant hunting expedition and the resulting multi-year evaluations of a group of *Camellia japonica*.

Domestic and international plant exploration, and subsequent evaluation of plant acquisitions have been important missions of the Morris Arboretum in recent decades. Since the late 1970s, staff of the Morris Arboretum have participated in 20 plant collecting trips, including trips to South Korea, China, the Caucasus Mountains, and regions within the United States. On these expeditions, seed is collected and returned to the Morris Arboretum for propagation. (Occasionally live plants are collected, but because of difficulties with transportation and import regulation, seeds are the primary form collected.) One of the main goals of our plant exploration and evaluation program is broadening the genetic pool of known species to extend cold hardiness and increase vigor.

Between 1979 and 1991, Morris Arboretum staff participated in five collecting expeditions to South Korea. These trips were planned to sequentially cover different geographic regions of South Korea. The 1984 Expedition to Korea's northwestern coast and islands (Korea Northwest Expedition – KNW) visited areas along the northwestern coast and inland to the Kwangnung Arboretum (now Korea National Arboretum) of South Korea (Meyer 1985). It is from this 1984 expedition that the Morris holds a number

MORRIS ARBORETUM OF THE UNIVERSITY OF PENNSYLVANIA

Map of areas visited on the 1984 Korea Northwest collecting expedition.

of accessions of *Camellia japonica* collected on Taechong and Sochong Islands, off the west coast of South Korea. The island collections represent some of the most northern collections ever made of common camellia. As an extension of the Asian land mass, Korea is exposed to a continental climate that includes strong, cold, and persistent winter winds. Even along the coast, the Korean climate is much harsher than that in Japan. As a result, despite their location in the Yellow Sea, these islands are exposed to more extreme temperatures than one would expect from their maritime location.

The Trip to the Islands

The idea of visiting and collecting from these island populations of *Camellia japonica* was instigated by Barry Yinger (Asiatica Nursery,

The Taean Peninsula on the northwest coast of South Korea. This area and islands off of the northwest coast were the focus of the 1984 Korea – Northwest collecting expedition.

Lewisberry, Pennsylvania), who had read of this northern cold-hardy population in the early 1980s (Yinger 1989a; Yinger 1989b). Through great persistence, Yinger first encountered these plants on Taechong and Sochong Islands in the winter of 1981. Yinger relates how his concern that the camellias were destroyed during the almost total deforestation of Korea during World War II turned to delight once he reached the islands. Yinger wrote about his first encounter with these camellias on Sochong Island:

> "... off we went, up the hillsides overlooking the Yellow Sea, buffeted by the cold wind from the northeast. The hillside was bleak and brown with few trees of any kind. The only greenery was an occasional grove of pines, the lower limbs of which had been chopped off for firewood. Up a little further and there—at last—a grove of camellias glittering green against the brown dried grasses, catching the winter sunshine and throwing it back to us." (Yinger 1989a)

By counting the growth rings of stumps of camellias that were cut for firewood, Yinger estimated the age of these trees, some of which were 15 to 18 feet (4.6 to 5.5 meters) tall, as close to 150 years old. These astonishing trees had silently witnessed the political vagaries that had affected the Korean peninsula and its people over that long period.

In October 1984, Yinger, then at the U.S. National Arboretum, returned to Taechong, Sochong, and Paekryong Islands with Sylvester March, Paul Meyer, and Peter Bristol (of the National, Morris and Holden Arboreta, respectively) along with their Korean colleagues Chang Yong June and Chang Yong Hun. Although these islands are controlled by South Korea they are located just south of the 38th parallel and north of the mainland border between North and South Korea. The islands are within view of North Korea, so they are of military and political significance; the explorers were required to

PAUL W. MEYER

Mature plants of *Camellia japonica* growing on a steep hillside on Sochong Island. Peter Bristol and Sylvester March are pictured at lower left.

have a naval escort to reach and travel on the islands and were forbidden from photographing the boat on which they travelled. As Meyer (1985) wrote:

> "... it must have been a peculiar sight as the Korean navy boat pulled out of Inchon Harbor. Among the Korean sailors were four American plant explorers eager to collect on a group of islands in the Yellow Sea. Piled high on the deck were herbarium presses, seed bags, and general expedition supplies. The pole pruners leaning against the gun turrets created a strange juxtaposition. If the North Koreans observed this they must have wondered what this unusual mission was all about."

Although the collecting supplies were exposed to the sea air, the Americans were sequestered below decks in crowded cabins for the duration of the long trip. Once on the islands, the collectors were escorted by the sailor companions, who eventually chipped in and helped with seed collecting and cleaning (trip details from Yinger 1989a and 1898b; Meyer 1985; and Meyer, personal communication).

The Americans travelled among the three islands for approximately one week, making a large number of collections from a great diversity of plants. Among these were nine seed collections of *Camellia japonica* including some

Collecting seeds from mature, open-grown *Camellia japonica* plants on Sochong Island. An unidentified Korean sailor is standing beneath the trees at left.

that were growing in pastures and others that had been transplanted into local farmers' gardens. Six of these came from Taechong Island and the other three from Sochong Island. The islands' inhabitants recognized the beauty of these plants and often transplanted them into their small home gardens. Meyer (1985) found a grove on Sochong Island to be the most impressive; here, the camellias grew into large trees that grew luxuriantly on a site exposed to sea winds and salt spray. The areas where they grew were heavily cut and grazed by goats. Only tall plants with their lower foliage eaten remained, and the grazing prevented any natural regeneration of seedlings. (Here at the Morris we have a similar problem, except it is the white-tailed deer that browse on our low hanging camellia foliage.)

The human and livestock pressure on the islands was significant and the field notes describe collecting from resprouting plants

Fruit of *Camellia japonica* collected on the 1984 Korea – Northwest expedition. The camellia fruit is a woody capsule containing several seeds.

in locations that were either cut-over forests, heavily grazed, or along roadsides. As unromantic as these types of plants and locations may sounds, they can make for excellent field

ARNOLD ARBORETUM

The handsome foliage of Japanese spicebush (*Lindera obtusiloba*) in golden fall color.

collecting. Compared to a mature forest, with little sunlight reaching the understory and fruits far out of reach, roadsides or regrown areas provide plants with sufficient sunlight to produce fruit while lending easy access to the plant collector.

In addition to the camellias, numerous other plants were collected on the islands, and many of these have grown exceptionally well for us. Most notable among these collections are *Callicarpa japonica, Lindera obtusiloba, Sorbus alnifolia, Styrax japonica, Pinus thunbergii,* and *Viburnum bitchuense.* Meyer (1985) was particularly impressed by seaside populations of *Styrax japonica,* which were noteworthy because of leathery and glossy leaves that were unaffected by salt spray or summer sun. Plants grown from this seed collection grace our parking lot where their May flowers provide a fragrant welcome to our visitors. Over the years we have lost many compound-leaved *Sorbus* species, but perhaps the best mountain ash for our area is *Sorbus alnifolia.* With its simple leaves, abundant white flowers, striking coral-red fruits, and russet fall color, the Korean mountain ash is one of my favorite plants throughout the year. Another standout from this group is *Lindera obtusiloba;* anyone who knows the sublime golden yellow fall color of Japanese spicebush agrees that it is one of the most outstanding shrubs for autumn foliage.

Wanted: A Hardy Camellia

What was the impetus that led to such effort to reach a far-flung corner of the world? As mentioned previously, camellias are exquisite garden flowers, but the vast majority of camellia cultivars are not hardy in regions colder than USDA hardiness Zone 7. From the late 1970s into the early 1980s a series of extremely cold winters devastated camellia collections at the U.S. National Arboretum and elsewhere (Ackerman 2007; Ackerman and Egolf 1992). At the National Arboretum alone, the harsh winters reduced the collection of 956 30- to 40-year-old plants to less than a dozen struggling survivors (Ackerman 2000; Ackerman and Egolf 1992). These severe winters—and the damage to large numbers of cultivars—inspired Dr. William Ackerman, a plant breeder and camellia aficionado at the National Arboretum, and Dr. Clifford Parks, a professor from the University of North Carolina in Chapel Hill, to undertake breeding programs to develop camellias cold-hardy in Zones 6 and 7. In light of the severe winters at the time of the Korean expeditions, there was considerable excitement about the potential for cold-hardy provenances of *Camellia japonica* coming from South Korea (Yinger 1989a). It was hoped that these northern collections of *Camellia japonica* would expand the hardiness of common camellia, generally considered to be reliably hardy in Zone 7 (Flint 1997) but historically not reliably cold hardy in the Philadelphia area (Zone 6b).

The nine accessions of *Camellia japonica* were collected on the Korean islands in October 1984, and some of these seeds were sown at the Morris Arboretum beginning in November of that year. Eight of the nine accessions germinated successfully, with varying numbers of seedlings among accessions. Given the northern locations of the parent populations, we began

a long-term field and garden trial of several accessions. Since the late 1980s plants grown from these collections have been evaluated for cold hardiness and several ornamental characteristics such as general vigor, leaf quality and retention, flower abundance and color, and plant habit. The camellias in this study all exhibit attractive evergreen foliage and single red flowers, which is typical of the straight species. These plants are large shrubs, reaching up to 12 feet (3.6 meters) tall or higher in 25 years. Although their single red flowers are not like the very showy forms grown farther south, their greatest value is in their hardiness and potential for breeding.

RICK J. LEWANDOWSKI

RICK J. LEWANDOWSKI

Field trials of *Camellia japonica* at the Morris Arboretum's Bloomfield Farm, February and April, 1994.

The Tryouts Begin

In 1986 plants were designated for one of two parallel evaluation studies: either a replicated field trial, or garden settings throughout the Arboretum. Of the eight successfully germinated accessions, six were eventually planted in the Arboretum's trials or throughout the Arboretum.

In April 1987, 730 seedlings were planted in a replicated field trial at the Arboretum's Bloomfield Farm research area and were evaluated for cold hardiness. From 1989 to 1993 all of these plants were evaluated for general foliage quality, vigor, and hardiness (survival) on a scale of 1 to 5 (with 1 being dead and 5 being excellent). As would be expected with seedling grown plants, there was great variation in the survival and quality of plants in this study (Aiello *et al.* 2008).

By June 1990, 589 plants survived, and 283 were deemed acceptable because they had a rating of 3, with only slightly damaged foliage. Three years later, in August 1993, the cutoff for retaining plants was elevated to a 4 ranking, that is, plants that showed only occasional foliar damage. At this level of scrutiny only 40 of 170 remaining plants made the grade. The winters of 1993–94 and 1994–95 resulted in further loss of plants, and by April 1995 the remaining plants were moved to our greenhouses. Then, between the fall of 1995 and spring of 1999, 25 of these highest rated plants from the original 730 in the Bloomfield trial were planted into the Arboretum's public garden for further assessment (Aiello *et al.* 2008).

In a parallel study, between 1987 and 1991 an additional 33 of the originally germinated seedlings that were not part of the formal field trial were planted in protected garden settings throughout the Arboretum. These plants did not receive the formal ratings applied to their siblings in the research plots. Nevertheless, the winters took their toll and by October 1999, 22 of these plants remained in the garden.

Bringing it All Together

In October 1999, shortly after I arrived at the Morris Arboretum, a total of 50 camellias were alive in garden settings throughout the Arboretum. Faced with what was already a 15-year old trial, I wanted to bring some resolution to this evaluation effort and to determine which of the remaining plants truly stood out among the others. The 50 plants included the 25 plants from the field trials, 22 remaining plants from those originally planted in garden settings, and three additional plants which had been cutting-grown in our greenhouse from original seedlings. These 50 plants were growing in protected areas throughout the Arboretum, where the camellias could grow under the canopy of conifers or against buildings, where they were shielded from strong winter winds and afternoon sun. For example, one group was massed to the north of a very large *Chamaecyparis pisifera* that screens our parking lot from Meadowbrook Avenue, a quiet residential street that borders our property. Another group was planted along the northeast face of Gates Hall, the Arboretum's administration building.

ANTHONY S. AIELLO

Camellia japonica **plants growing at Gates Hall at the Morris Arboretum.**

Starting in the fall of 1999 and continuing through the spring of 2004, the 50 plants throughout the Arboretum were visually evaluated. In the spring and fall of each year the plants were rated for a variety of ornamental traits including general vigor, hardiness, leaf retention, and foliar and floral characteristics. Plants with foliage that was deep green, glossy, disease-free, and with no winter injury received the highest ratings. Although there was not a great deal of variation in floral traits, plants with greater numbers of flower, flowers that were more open, and flowers with richer bright scarlet color were considered the most desirable. There was also significant variation in plant habit and we gave higher ratings to denser and more regularly shaped plants (Aiello *et al.* 2008).

After these visual evaluations were completed in late 2004, 43 plants remained alive and each year's ratings for these plants were combined. These 43 plants were grouped into three categories according to overall performance and appearance after 5 years of evaluation. These categories were somewhat subjective but allowed us to consolidate several seasons of information into a shorthand that would clarify the better performing plants.

Of the 43 plants, the top 15 ("A" rating) exhibited consistent, positive performance in three key areas of the evaluation criteria. In particular, these plants flowered every year, maintained a desirable habit, and retained attractive glossy green foliage throughout the seasons. The foliage quality is especially important in March, when the effects of winter start to show on poorer performing plants. Because *Camellia japonica* flowers on old wood before new growth emerges, we were especially interested in those plants that retained high quality foliage as the flowers emerged from March into April. The middle 16 plants ("B" rating) generally performed well in one or two areas of the evaluation, but their performance was either not consistent, or was poor in the other categories. For instance, "B" plants may have had good foliage quality but their flowering was poor or inconsistent, or they might have had beautiful flowers but scraggly open habits that detracted

from the overall quality of the plant. The lowest rated 12 plants ("C" rating) generally performed poorly in several categories. In some instances, they may have exhibited one positive characteristic, but this was overridden by the overall appearance of plant.

The Current Situation and Next Steps

After more than 20 years of evaluation, the numbers of Korean *Camellia japonica* at the Arboretum has gone from approximately 750 plants to just over 40 individuals. The remaining plants represent six of the original nine collections from Korea (KNW 312, 342, 344, 348, 350, and 352) and are a valuable genetic resource for introduction and breeding. Although their ornamental value may not compare to cultivars hardy in the southern and western United States, our plants exhibit attractive single red flowers and glossy evergreen foliage. They represent a significant advance in the hardiness of common camellia, with suitability for Philadelphia and the mid-Atlantic region, and possibly the lower Ohio Valley and coastal New England. These cold-hardy selections will appeal to Zone 6 gardeners who have coveted these plants after visiting the "Camellia Belt" found in southeastern and West Coast states.

Along with evaluating the remaining plants in our collection, over the past several years we have been propagating and distributing cutting-grown individuals from our highest rated plants. Camellias have been provided to other public gardens throughout the northeastern United States, including Chanticleer, and the Scott, Tyler, Willowwood, Polly Hill, and Arnold Arboreta. Our hope is that distributing this material will help conserve the germplasm and provide evaluation over a broader range of climates.

ANTHONY S. AIELLO

Camellias with glossy green foliage that remained attractive through the winter received higher ratings in the evaluation.

ANTHONY S. AIELLO

Single, red flowers were standard for the Korean seedlings, though some plants had more vibrant color or greater numbers of flowers.

Currently we are planning to name and introduce several individual plants from our *Camellia japonica* trials (see sidebar). Two of these plants are those that show the highest ratings for combination of plant habit, foliar quality, and flower density. One plant shows a striking upright habit and a fourth is consistently precocious, regularly blooming in late autumn compared to the normal early spring blooming time of the species.

Presently there are three commercially available introductions from the 1984 Korean *Camellia japonica* collections. These are: 'Korean Fire' (KNW 352) a 2003 Pennsylvania Horticultural Society Gold Medal winner that was introduced by Barry Yinger through Hines Nursery (Bensen 2000); and 'Longwood Valentine' and 'Longwood Centennial' (KNW 350) introduced by Longwood Gardens (Tomasz Aniśko, personal communication).

Going forward, our goal is to distribute our selections and compare them to other known cold-hardy forms of *Camellia japonica*. We are also working with plant breeders to share material in the hope that the hardiness inherent in our plants can be utilized to develop cold-hardy varieties with greater variation in flower color and form. Much of the work in developing cold hardy camellias has been conducted by Dr. Ackerman and Dr. Parks (Aniśko 2000). Additionally, Longwood Gardens continues a long research program in breeding and selecting camellias (Aniśko 2000).

The evaluation of woody landscape plants is a long-term commitment, one that often spans the tenures of staff at institutions that

New Camellia Introductions

There are four plants that we are planning to name and introduce. The varietal names and descriptions of these are as follows. All heights are approximate.

'Balustrade' (86-043*J / KNW 342). One of two plants at the Studio Building, a small office building near our administrative offices. This plant has a very narrow, upright habit and strongly upright branch angles. This plant has been growing in its current location since the spring of 1988 and is 11 feet (3.4 meters) tall and 3 feet (.9 meter) wide. The single flowers are a good scarlet red, typical of the species. It received an overall "A" ranking and flowered every year, with excellent lustrous foliage.

'Meadowbrook' (86-050*U / KNW 352). One of a grove of plants growing on the north side of a large *Chamaecyparis pisifera* along Meadowbrook Avenue, near the Arboretum's parking lots. This plant has outstanding blue-green foliage. It has been growing in its current location since December 1995 and is 12 feet (3.6 meters) tall and 6 feet (1.8 meters) wide. Its flower color is a rosy red and lighter in color than others that we have evaluated. It received an overall "A" ranking, flowered every year, and had especially high marks for foliage quality; its attractive lustrous foliage stands out for its high quality in all seasons. It is fully branched to the ground with an ovate habit.

'Bloomfield' (86-050*W / KNW 352). Another in a grove of plants growing on the north side of a large *Chamaecyparis pisifera* along Meadowbrook Avenue, near the Arboretum's parking lots. This plant combines the best flowering of all of our plants with excellent foliage quality and vigorous growth. This plant has been growing in its current location since December 1995 and is 16 feet (4.9 meters) tall and 9 feet (2.7 meters) wide. The single flowers are scarlet red, typical of the species. It received an overall "A" ranking, flowered every year, and had especially high marks for foliage quality and habit. This was ranked the number one overall plant of the entire evaluation. It is fully branched to the ground with an excellent ovate habit.

'Morris Mercury' (86-050*Z9 / KNW 352). One of a group of plants growing on the north side of Gates Hall, the Arboretum's administrative offices. This is a precocious, fall blooming plant. This plant has been growing in its current location since October 1999 and is 11 feet (3.4 meters) tall and 7 feet (2.1 meters) wide. It has a more open habit than the others, with an upright arching branch habit. This plant blooms regularly in November of each year, with sporadic blooms the following spring. Despite flowering every year, it received an overall "B" rating due to its open habit and foliar damage after cold winters of 2000 and 2001.


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***Camellia japonica* plants growing along Meadowbrook Avenue at the Morris Arboretum. 'Bloomfield' (Morris Arboretum 86-050*W) is pictured at the center of this photograph.**

A *Camellia japonica* grown as an espalier in a protected spot at the Morris Arboretum.

collect, propagate, and evaluate these plants. At the Morris Arboretum we have found that plants collected in the 1980s in South Korea have exceptional cold hardiness and adaptability. For example, stems from *Cornus kousa* that were also collected on the 1984 KNW expedition showed significantly more freezing tolerance in tests than plants of either Japanese or Chinese origin (Aiello 2005). Likewise, after more than 20 years of evaluation, the Korean *Camellia japonica* plants represent some of the most cold-hardy collections ever made of common camellia. These collections may extend the hardiness of *Camellia japonica* into more northern areas and bring the spring pleasure of camellias to eager gardening audiences.

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Searching for Exotic Beetles

Nichole K. Campbell

When non-native species of plants, animals, and disease organisms are introduced to other regions they have the potential to become serious pest problems in their new location. Concern over the introduction of potentially damaging species has led the Plant Protection and Quarantine (PPQ) program—part of the USDA Animal and Plant Health Inspection Service—to increase its domestic surveillance for non-native species in the United States over the past several years.

Most exotic (non-native) species enter the United States through international movement of people, commodities, and conveyances. Most are accidental introductions, though some intentional introductions (primarily plants) have turned out to be invasive pests. Not all introduced species become agricultural or forest pests; typically, one in seven exotic species is considered invasive. There is often a lapse between the time the pest is introduced and the time that the pest is discovered or reported in the United States; unfortunately this often allows new pest populations to build.

Beetle Patrol

In 2009, PPQ is conducting exotic beetle trapping around the Boston port area as part of the USDA's national wood borer and bark beetle survey. The Boston port area may be a high-risk

PETER DEL TREDICI

A cargo ship heads toward the port of Boston, passing between Spectacle Island and Deer Island in Boston Harbor.

area for the introduction of new exotic forest pests because of the high volume of cargo imports that enter the United States through it.

Commodities entering the port are often shipped in solid wood packing material, a potential harbor for insect pests of trees. Prior to 2005, there were no regulations requiring the treatment of solid wood packing material for the prevention of pest introductions. Today, all foreign solid wood packing material must be fumigated or heat treated to prevent new forest pests from entering the United States through that very high-risk pathway.

The goals of the USDA's national wood borer and bark beetle survey are to obtain information about:

- The presence, distribution, or absence of target species.
- The advent of new species.
- Patterns of distribution throughout the United States and possible pathways for introduction.
- The phenology of target exotic species in the United States and their selection of hosts.
- The characteristics of high-risk habitats or sites.
- The survey methods themselves.

When selecting survey sites, we primarily target cargo transport companies, businesses that receive imports, and areas around the port of entry where there are host trees that could support the establishment of exotic beetles.

PPQ has chosen twenty locations within 15 miles of the port of Boston for the wood borer and bark beetle survey. One of the sites chosen this year is the Arnold Arboretum because of its close proximity to the Boston port and the presence of a wide variety of tree species in its collections.

NICHOLE K. CAMPBELL

One of the Lindgren funnel traps at the Arnold Arboretum.

Setting the Trap

The survey involves trapping and identifying beetles in order to determine if exotic species are present in the area. We placed three Lindgren 12-funnel traps at each of the twenty selected locations for a total of sixty traps in the Boston area. Each trap is baited with one, or a combination, of the following lures: ultra high release ethanol, ultra high release alpha-pinene, or the 3-ips lure. The volatiles in the lures simulate stressed or dying hardwood and softwood trees, the types of host trees that many of the exotic beetles are attracted to.

The traps are hung in trees, on poles, or on fences near target hosts. Traps are placed a minimum of 25 meters (82 feet) apart to prevent volatiles from mixing in the air and deterring beetles. Each trap has a collection cup at the bottom that is filled with non-toxic antifreeze to preserve the collected beetles. The trapping period will last from mid March through the end of August to cover a range of emergence periods of the target beetles. Bark and ambrosia beetles typically emerge in early to late spring, while larger wood-boring beetles typically emerge later in summer through fall. The traps are serviced on a bi-weekly schedule to collect any trap contents and replace lures as needed.

All of the trapped beetles will be sent to the Carnegie Museum of Natural History, Section of Invertebrate Zoology, in Pittsburgh, Pennsylvania. They will be screened by qualified experts to determine if they are the target exotic beetles or other non-native beetles.

Determining the potential invasiveness of these exotic beetles is difficult since there is very little research information available for most of them. Often, they are not studied in their native countries if they do not cause eco-

nomic damage there. We can't predict exactly how an introduced beetle species will affect forests in the United States, but experts do try to make educated guesses.

If any exotic beetles are found they will be confirmed by PPQ experts, and state and local authorities will be notified. The USDA's New Pest Advisory Group (part of PPQ), in conjunction with state and local officials, would then evaluate the new pest risk and determine the appropriate action to take to protect our national forests and agricultural industries.

A Gallery of Beetles

Here are some of the exotic beetles targeted in the survey:

Hylurgus ligniperda (Red-haired Pine Bark Beetle)

NATIVE: Europe, Mediterranean areas, Africa, and parts of Asia

ENTERED U.S.: Introduced near Rochester, New York, in 1994. Found in a Lindgren funnel trap. Has been found in four counties.

HOST: *Pinus* spp. (pines) preferred. Also, *Abies* spp. (firs); *Larix* spp. (larches); *Picea* spp. (spruces); *Pseudotsuga* spp. (Douglas-firs)

DAMAGE: Affects bark, stem, root, trunk, and seedlings. Feed and develop in tunnels beneath the bark. They are know vectors of the root disease fungi *Leptographium* spp. and *Ceratocystis* spp.

WILLIAM M. CIESLA, FOREST HEALTH MANAGEMENT INTERNATIONAL, BUGWOOD.ORG

Red-haired (or golden-haired) pine bark beetles under the bark of a Monterey pine (*Pinus radiata*).

Ips sexdentatus (Six-toothed Bark Beetle)

MILAN ZUBRIK, FOREST RESEARCH INSTITUTE – SLOVAKIA, BUGWOOD.ORG

Six-toothed bark beetles in galleries.

NATIVE: Mainland Asia and Europe

ENTERED U.S.: Has been intercepted at ports of entry. Has not been found domestically beyond ports.

HOST: *Pinus* spp. (pines) preferred. Also, *Abies* spp. (firs); *Larix* spp. (larches); *Picea* spp. (spruces); *Pseudotsuga* spp. (Douglas-firs)

DAMAGE: Affects inner bark, leaf, stem, and whole plant. Mates, develops, and feeds in tunnels beneath the bark. Mainly attacks stressed or dying trees. It can kill trees of commercial importance. It also introduces blue stain fungi (*Ophiostoma* spp.) into host trees which hasten the death of tree, discolor wood, and can result in loss of lumber grade and value.

Two Highly Destructive Exotic Beetles

Unfortunately, many exotic wood-boring beetles are not attracted to traps baited with volatiles and can only be surveyed for visually. This requires trained spotters using binoculars from ground level, or professional tree climbers knowledgeable in insect signs and symptoms. The **Asian longhorned beetle (ALB)** (***Anoplophora glabripennis***) is a highly destructive invasive beetle that can only be surveyed for in this manner. There is ongoing research to identify more effective survey methods for this devastating pest.

Larvae of the Asian longhorned beetle tunnel into the heartwood of live healthy trees, eventually killing their hosts. Favored species are maples, birches, Ohio buckeye, elms, horse chestnut, and willows. ALB, and efforts to eradicate it, have resulted in the loss of thousands of street trees in several states. ALB was detected in Worcester, Massachusetts, in August, 2008, and its potential spread is of great concern in New England. Volunteers will be educated to survey for ALB throughout Massachusetts this year. Visual surveys and education outreach for ALB will be conducted in all New England states during 2009. For more information about ALB, please visit: http://www.aphis.usda.gov/oa/alb/alb.html or http://massnrc.org/pests/alb/

Emerald ash borer (EAB) (***Agrilus planipennis***) is another highly destructive beetle that has spread in regions of the United States and Canada. EAB attacks ash trees (*Fraxinus* spp.) and has been moved from its introduction point in Michigan to other states primarily through movement of nursery stock and firewood. We have not detected EAB in Massachusetts yet, but a survey for it is planned for this year. The Massachusetts Department of Conservation and Recreation, Division of Forestry, will place purple panel sticky traps baited with lures at twenty high-risk locations such as campgrounds, nurseries, and wood processors. Currently, there are no plans to trap inside the Arnold Arboretum for EAB because it is not a high-risk location for the introduction of this pest. For more information about EAB, please visit: www.emeraldashborer.info

DAVID CAPPAERT, MICHIGAN STATE UNIVERSITY, BUGWOOD.ORG

Ips typographus (European Spruce Bark Beetle)

NATIVE: Europe and Asia

ENTERED U.S.: Has been intercepted in traps in Indiana (1995) and Maryland (2002). It is not known to be established in the U.S.

HOST: *Picea* spp. (spruces) preferred. Also, *Abies* spp. (firs); *Larix* spp. (larches); *Pinus* spp. (pines); *Pseudotsuga* spp. (Douglas-firs)

DAMAGE: Affects bark, crown, foliage, leaf, stem, and whole plant. Considered one of the most serious pests of spruce in Europe. It vectors a blue stain fungus (*Ceratocystis polonica*) which can also kill the host. It causes major economic losses when it is in outbreak numbers and can cause severe decline in spruce populations within its native range. Males aggregate and colonize a stressed tree by boring into the bark and preparing nuptial chambers. The females are then attracted to the chambers to mate. The females lay eggs in maternal galleries where the larva will develop. They can have multiple generations in a year depending on temperature.

MILAN ZUBRIK, FOREST RESEARCH INSTITUTE - SLOVAKIA, BUGWOOD.ORG

Dead spruce trees in Slovakia, killed by European spruce bark beetles.

Xyleborus seriatus (No common name; very little is known about this beetle.)

NATIVE: China, Russia, Japan, Korea, Taiwan

ENTERED U.S.: Intercepted in Lindgren trap in Massachusetts in 2005, the first North American record. This beetle was also trapped in Maine in 2008.

HOST: *Acer* spp. (maples), *Aesculus* spp. (buckeyes), *Alnus* spp. (alders), *Betula* spp. (birches), *Cryptomeria* spp., *Fagus* spp. (beeches), *Larix* spp. (larches), *Pinus* spp. (pines), *Prunus* spp. (cherries), *Quercus* spp. (oaks), *Thuja* spp. (arborvitae), *Tsuga* spp. (hemlocks), etc. Large possible host range.

DAMAGE: Very little data. Is known to be associated with *Ambrosiella* fungi. Spores of a symbiotic fungi are carried on their bodies to new galleries. Larvae and adults feed on this fungi growing between the bark and sapwood. Thought to be a secondary pest and will not kill healthy trees. Several *Xyloborus* species are potential survey targets.

Xylotrechus hircus (No common name; very little is known about this beetle.)

NATIVE: Native to Eastern Russia, China, Korea

ENTERED U.S.: Intercepted in Lindgren trap in Oregon in 1999; not known to be established.

HOST: *Betula* spp. (birches)

DAMAGE: No information available. Species damage unknown. Several *Xylotrechus* species are potential survey targets.

Nichole K. Campbell is a pest survey specialist with the USDA, APHIS, Plant Protection and Quarantine program.

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Items in **boldface** *refer to illustrations.*

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Index compiled by Rosalie Davis.

Early Bloomer: *Hydrangea paniculata* 'Praecox'

Sue A. Pfeiffer

During the second half of the nineteenth century, the latest trend in the gardening world was the acquisition and display of exotic plants. At the time, Darwin's theory of evolution was changing the scientific community, and Harvard botanist Asa Gray's paper noting the similarities between eastern North American and eastern Asian floras had recently been published.

By the early 1890s, the still young Arnold Arboretum was beginning to take shape. C. S. Sargent, the first director of the Arboretum, had become highly interested in Gray's work comparing our native flora to that of eastern Asia. His desire to plant the Arboretum with every tree capable of surviving the New England climate led him to seek exotic Asian species from similar climates. Although European plant species were easily obtained, acquiring plant material directly from Asia was still difficult during this era. Wanting to view the native flora and personally judge the plants for their landscape value, Sargent set off on a ten week expedition to Japan in the fall of 1892. He collected extensively on the islands of Hondo and Yezo (now known as Honshu and Hokkaido), returning with seeds of 200 species, including *Hydrangea paniculata*, panicle hydrangea.

Hydrangea paniculata is native to Japan and southern Sakhalin Island in Russia as well as eastern and southern China where it is typically found in mixed forests or open hillsides. A large shrub or small tree, panicle hydrangea may reach 20 feet (6 meters) in height, though in New England landscapes a mature height of 10 to 13 feet (3 to 4 meters) is typical. Its large, simple, dark green leaves have toothed margins and a slightly undulating surface. Panicle hydrangea produces conical compound inflorescences 6 to 8 inches (15 to 20 centimeters) in length at the tips of branches. The inflorescences are comprised of two types of florets; a large number of small, cream-colored, fertile florets, plus a scattering of larger, showier, white, sterile florets. The sterile florets often become speckled or flushed with pink as they age. In New England the species flowers from early August into September.

When plants were grown from the *Hydrangea paniculata* seeds collected by Sargent, one was observed to flower far earlier in the summer than the others. Sargent noted this early bloomer in an issue of the Arboretum publication *Garden and Forest* in September 1897, less than five years after the seed was collected. Several years later, the plant was named 'Praecox' (meaning "premature".) by Arboretum taxonomist Alfred Rehder. *Hydrangea paniculata* 'Praecox' is a vigorous, fast growing, erect shrub which tends to flower three to six weeks earlier than the species. At the Arboretum it typically starts to bloom in early to mid July. Its beauty in the landscape was described in 1922 by Sargent himself: "When in flower in early July it is one of the handsomest shrubs in the Arboretum," and in 1927 by E. H. Wilson: "Well worth the attention of all interested in hardy plants."

At the Arboretum, the original plant—now 116 years old—can be found in the Bradley Rosaceous Collection. Although not a member of the rose family, the plant (accession 14714-A) has remained in its original location (formerly the Shrub Collection) because of its importance as a type specimen. The plant is now 15.5 feet (4.7 meters) tall and 24.5 feet (7.5 meters) wide. Every July, visitors are drawn to its incredible display of flowers borne on the many arching stems clad in handsome gray-brown exfoliating bark. Another specimen (accession 14714-1-A), propagated from the original plant in 1905, stands nearby and is equally impressive.

Panicle hydrangeas have become very popular in the nursery trade in recent years, and many new cultivars have been introduced. 'Praecox' remains the earliest blooming cultivar and is valuable for extending the panicle hydrangea bloom season. While not as readily available as some cultivars, 'Praecox' is well worth seeking out and acquiring.

Sue Pfeiffer is a Curatorial Fellow at the Arnold Arboretum.




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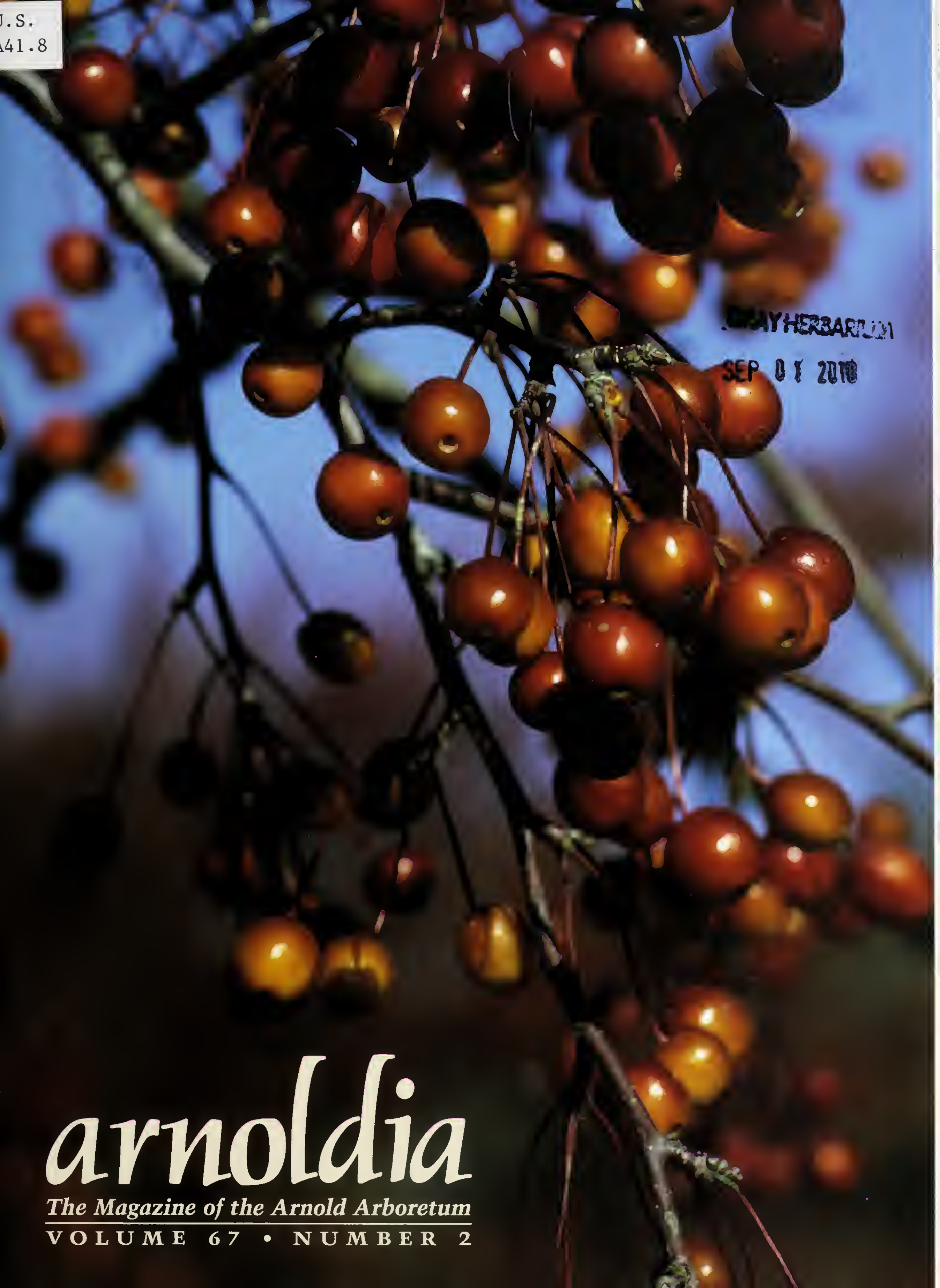

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Front cover: Malus 'Indian Magic' presents a stunning display of red-orange fruit in the autumn. Photo by Nancy Rose.

Inside front cover: Noted for its elegantly striped bark, *Acer davidii* is one of many plants named in honor of Father Armand David. Photographed in China's Min Shan mountains in 2005 by Kris Bachtell.

Inside back cover: The original specimen of *Acer rubrum* 'Schlesingeri' (accession 3256-A) provides an early show of fall color at the Arboretum. Photo by Nancy Rose.

Back cover: This early 20th century poster prompts Bostonians to visit the crabapple (*Malus*) collection at the Arnold Arboretum via elevated train car. Archives of the Arnold Arboretum.

Crabapples . . . With No Apologies

Jeff Iles

NANCY ROSE

An oldie but a goodie, red-flowered 'Liset' is still a popular crabapple.

One of my favorite older horticulture books is a signed copy of *Ornamental Crabapples* by Arie F. den Boer. Published in 1959 by the American Association of Nurserymen, this little manual was perhaps the first successful attempt at popularizing the various species, varieties, and cultivars of crabapples (those taxa in the genus *Malus* bearing fruits 2 inches in diameter or smaller). I like the book because it provides a unique glimpse back to an era when selections like 'Aldenhamensis', 'Almey', and 'Dorothea' ruled the nursery sales yards. Those cultivars are rarely seen today but others described in the book, including *Malus floribunda,* 'Liset', 'Profusion', and 'Red Jade', *have* prevailed and would be totally appropriate in today's landscapes.

What I really enjoy about the book, though, is the author's unapologetic and matter-of-fact acceptance of crabapples, warts and all. For example, he begins the chapter on insect and disease pests with this blunt statement: "It should not be considered strange or disturbing that apples and crabapples are visited once in a while by some unwelcome guest." You have to admire Mr. den Boer's understated admission

that certain members of the genus *Malus* do have pest issues, but the reality is few landscape plants are problem-free.

Yet for some reason crabapples are subjected to much disrespect by certain detractors, even those who readily accept the premise that most landscape plants aren't perfect. Crabapple naysayers are happy to share their tales of crabapple woe, particularly when they involve susceptibility to foliar diseases ("My Uncle Vito over in Dubuque had a crabapple in his front yard that would defoliate completely every July.") or fruit litter ("You think that's bad... my Aunt Betty had one that would drop loads of rotting, messy fruit all over her patio every summer.") These repeated knocks against crabapples often trace to plantings of once-popular, older crabapple cultivars such as 'Hopa' and 'Radiant'. Originally embraced for their head-turning spring flower extravaganzas, these cultivars are now sadly, and maybe a bit unfairly, remembered only for debilitating disease problems and overly large, non-persistent fruit. Unfortunately, a sufficiently large population of 'Hopa', 'Radiant', and other less-than-stellar cultivars still can be found in present day landscapes, reinforcing the misperception that *all* crabapples defoliate in July and double as fast-food emporiums for every yellow jacket wasp in the neighborhood.

But surely we—whether plant scientists or backyard gardeners—should understand the folly of making blanket statements about a group of plants with upwards of 900 named selections. After all, a family (in the non-taxonomic sense) that large is bound to produce a few bad apples, if you'll excuse the pun.

Why Crabapples Still Rule

The fact is that crabapples remain atop the list of small ornamental trees used in residential and commercial landscapes in USDA hardiness zones 4 through 7 for many very good reasons. Crabapples offer an avalanche of fragrant and colorful spring flowers in white and

JEFF ILES

Select apple-scab-resistant cultivars in order to avoid the heartbreak of mid summer crabapple defoliation.

JEFF ILES

Malus floribunda sports beautiful pink buds and white flowers.

JEFF ILES

Crabapples with persistent fruit provide months of color.

The weeping branches of 'Red Jade' laden with bright red fruit.

shades of red ranging from palest pink to deep burgundy. As an added spring attraction, many crabapples display beautifully contrasting colors as the flower evolves from tight bud stage to fully opened flower—for example, deep pink buds opening to white flowers or deep red buds becoming bright pink flowers. Most crabapples have handsome foliage with leaf color ranging from dark green to burgundy. Though generally not noted for fall foliage color, some crabapples including *M. tschonoskii* and 'Satin Cloud' develop eye-catching shades of orange, crimson, and purple, while others flaunt hues of apricot ('Prairie Maid') and golden-yellow ('Amberina' and 'Red Swan'). Providing as spectacular a display as their spring blossoms but much longer lasting, the best crabapples bear bushels of vividly-colored fruit that enliven the fall and winter landscape. Another plus is the broad array of growth habits and mature sizes that makes it possible to choose a crabapple for practically any landscape situation. Finally, when planted on appropriate sites (well-drained soils and full sun) and given modest annual care, crabapples can have a functionally effective life of at least 40 to 50 years, and sometimes much longer.

Where Do They All Come From?

There are interesting stories behind the discovery, naming, and introduction of every species, variety, and cultivar of crabapple. From *M. baccata,* gleaned from the wilds of Siberia and named by Linneaus in 1767, to modern cultivars that owe their existence to countless crosses and backcrosses, one has to marvel at the imagination, determination, and luck required to bring a single crabapple selection to the attention of the gardening public. As an illustration, consider the circuitous birthing path for the much admired weeping crabapple 'Red Jade'.

The 'Red Jade' story begins in the early to mid 1800s in northeast Asia with the discovery and introduction of *Malus prunifolia.* The plumleaf crabapple was known for having many forms, and as luck would have it, a weeping form was

JEFF ILES

A Father Fiala introduction, 'Orange Crush' crabapple is gaining popularity.

discovered and given the cultivar name 'Pendula'. Later, *M. prunifolia* 'Pendula' was crossed with *M. floribunda* (Japanese flowering crabapple) with the result being a small, weeping tree eventually dubbed *M. floribunda* 'Exzellenz Thiel'. Selected by Späth Nursery in Germany and introduced to North America by the Arnold Arboretum in 1912, this diminutive, disease-prone crabapple was one of the first weeping ornamental trees used in the United States. In 1935 serendipity stepped in as Dr. George M. Reed of the Brooklyn Botanic Garden either discovered or purposely germinated and grew open-pollinated seedlings from *M. floribunda* 'Exzellenz Thiel'. What initially captured his attention isn't clear, but one of those seedlings developed into a beautiful weeping tree. In 1953 it was given the cultivar name 'Red Jade'; the name remains a bit of a mystery but probably refers to the bright red, ½ inch diameter fruit and the glossy "jade" green foliage, two notable and recognizable features of the cultivar.

Now fast-forward to one of today's rising stars, *M.* 'Orange Crush'. This delightful introduction sports orange-crimson flowers, handfuls of deep maroon fruit, and excellent disease (and Japanese beetle) resistance. But its existence and subsequent rise to fame comes only after a mind-numbing series of crosses, ending finally when Father John Fiala crossed *M.* 'Liset' with *M.* 'Red Swan'. And you can bet *M.* 'Orange Crush' will join the hybridization dance many times before it's put out to pasture.

Selecting the Right Crabapple

Finding a great crabapple for your landscape is pretty easy these days. The vast majority of crabapples now sold in nurseries and garden centers have much improved resistance to disease compared to their predecessors, and also feature highly ornamental fruit that is either small in size, persistent, or relished by our winged friends.

The decision to include one or several crabapples in a landscape planting really hinges on several factors. First and foremost, the tree you choose must fit the site. For example, if you don't have sufficient room for a large tree (stan-

NANCY ROSE

Dense-crowned 'Coralcole' (Coralburst®) crabapple fits in smaller spaces.

dard crabapples typically grow 20 to 25 feet tall and wide), you might consider one of several dwarf selections such as 'Camzam' (Camelot®), 'Cinzam' (Cinderella®), 'Coralcole' (Coralburst®), or 'Lanzam' (Lancelot®). And if you like the somewhat formal look of dwarf forms top-grafted to a standard, then you must investigate the aptly-named 'Lollizam' (Lollipop®) and two *Malus sargentii* selections, 'Select A' (Firebird®) and 'Tina'. If you're looking for an upright-growing selection that will pose minimal problems for pedestrian and vehicular traffic, the increasingly popular 'Adirondack' (selected by Don Egolf at the United States National Arboretum) is the crabapple for you. But if space constraints aren't an issue (parks, golf courses, entryway plantings, large residential lots, etc.) imagine the visual impact of informally arranged drifts (5 to 9, or more) of red-flowering 'Cardinal', red-fruited 'David', or gold-fruited 'Schmidtcutleaf' (Golden Raindrops®).

Next, consider special maintenance issues such as disease susceptibility. In a perfect world, we'd quickly rule out using crabapple

JEFF ILES

White-flowered 'Adirondack' has a tidy upright-vase shape. The crabapple to the right is 'Purple Prince'.

JEFF ILES

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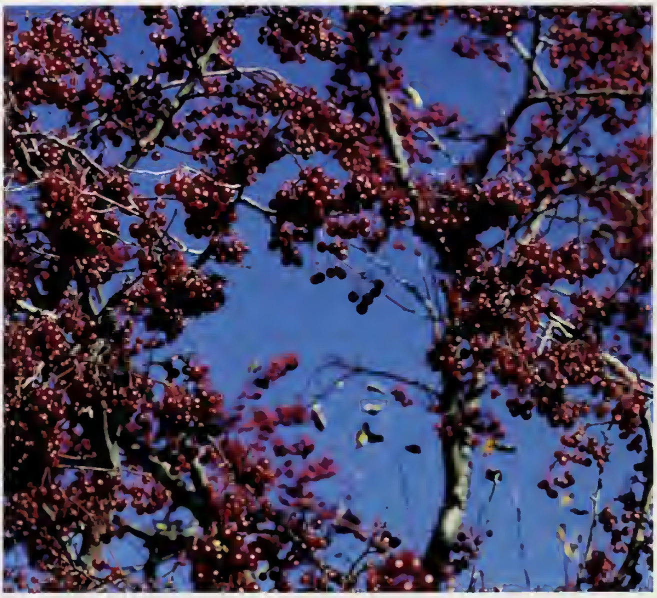


Clockwise from upper left:
'Camzam' (Camelot®)
'Jewelcole' (Red Jewel™)
'David'
'Donald Wyman'
'Schmidtcutleaf' (Golden Raindrops®)

The "Best" Crabapples (*Malus* spp.)

TAXA	FLOWER	FRUIT	HT/WD	FORM	FOLIAGE
'Adirondack'	white	orange-red (½")	18'/10'	upright (inverted cone)	dark green
Limitations: slow-growing					
'Camzam' (Camelot®)	fuchsia-pink	burgundy (⅜")	10'/8'	rounded/compact	dark green/burgundy
Limitations: not much late-season interest					
'Cardinal'	pinkish-red	deep red (½")	16'/22'	broadly spreading	dark purple-red
Limitations: none known					
'Cinzam' (Cinderella®)	white	gold (¼")	8'/5'	rounded, upright	light green
Limitations: slow-growing					
'David'	white	scarlet (⅜")	15'/20'	rounded	light green
Limitations: alternate bloom; light apple scab noted; fruit mummies persist until spring					
'Donald Wyman'	white	bright red (⅜")	20'/20'	rounded	medium green
Limitations: apple scab noted; fruit mummies persist until spring					
floribunda	pink-white	amber (⅜")	12'/20'	spreading/irregular	medium green
Limitations: unimpressive fall fruit display					
'Schmidtcutleaf' (Golden Raindrops®)	white	golden-yellow (¼")	20'/15'	upright	medium green/deeply cut
Limitations: alternate-year bloom; fire blight has been reported					
'Lanzam' (Lancelot®)	white	gold (⅜")	10'/8'	oval	medium green
Limitations: flowers/fruit borne on interior of the tree which diminishes their ornamental effect					
'Louisa'	rose-pink	amber (⅜")	10'/15'	weeping	dark green/glossy
Limitations: fruit are ornamentally insignificant					
'Orange Crush'	rose-red	red (⅜")	15'/15'	rounded	purplish-green
Limitations: none known					
'Prairie Maid'	deep pink	red (⅜")	15'/15'	rounded	medium green/yellow-apricot fall
Limitations: none known					
'Prairifire'	pinkish-red	dark red (½")	20'/20'	rounded	purple turning reddish-green
Limitations: requires pruning to correct overcrowded branching					
'Purple Prince'	rose-red	maroon (½")	20'/20'	rounded	purple turning bronze-green
Limitations: heavy fruit production may weigh branches down					
'Jewelcole' (Red Jewel™)	white	red (½")	15'/12'	pyramidal	medium green
Limitations: none known					
'JFS-KW5' (Royal Raindrops®)	pinkish-red	red (¼")	20'/15'	upright	purple cutleaf/orange-red in fall
Limitations: none known					

NANCY ROSE

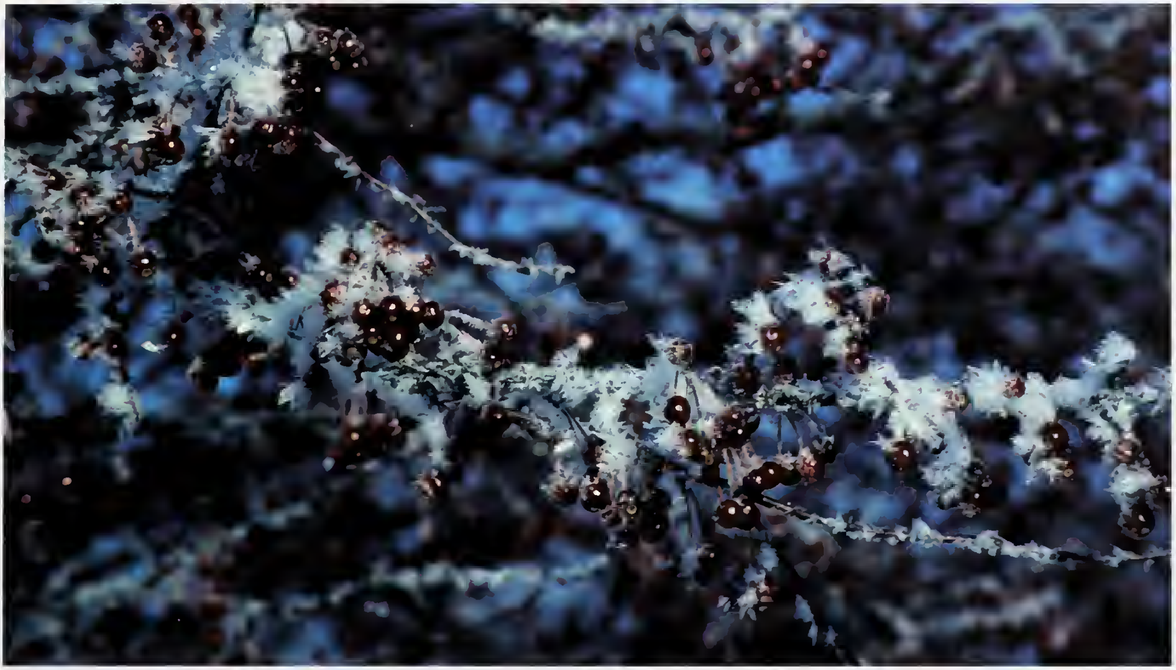
This specimen of 'Bob White' shows just a few spots of apple scab on its leaves.

NANCY ROSE

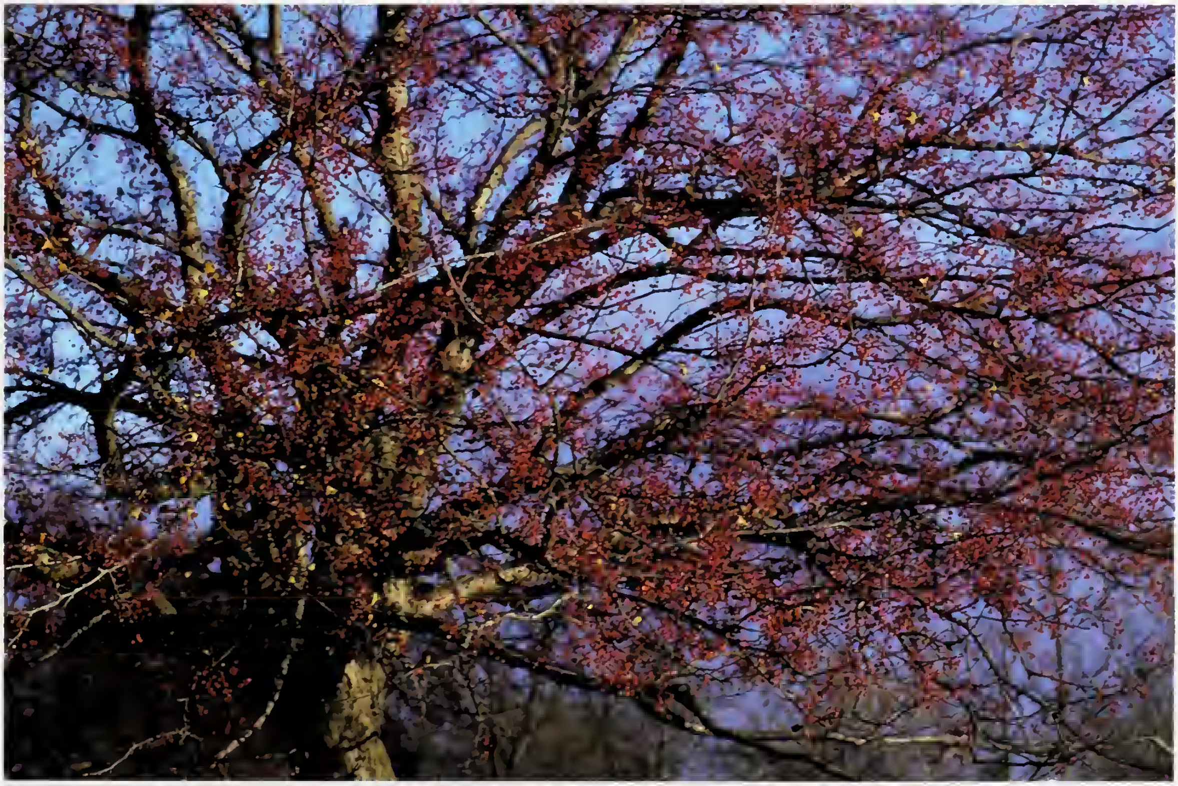
If only Aunt Betty had planted her 'Dolgo' crabapple (shown here) out in the yard instead of next to the patio she wouldn't have a crabapple mess underfoot.

selections with poor resistance to fungal pathogens *Venturia inaequalis* (apple scab) or *Botryosphaeria obtusa* (frogeye leaf spot) responsible for premature defoliation, and would never entertain the addition of a crabapple susceptible to the bacterium *Erwinia amylovora* (fire blight). The fungal prankster responsible for apple scab (actually, there are several races of *V. inaequalis*) has been especially frustrating for crabapple lovers because resistance to scab apparently is not a forever kind of thing (or, is not a permanent and binding contract between pathogen and host). In fact, all it takes is one lucky "super" ascospore infecting a previously resistant crabapple host to begin the process of resistance breakdown in that host. Notable examples of resistance breakdown and the subsequent development of scab have occurred on *Malus* 'Prairifire', 'Bob White', 'Jewelcole' (Red Jewel™), and *floribunda*. But sometimes positive attributes outweigh the negative, and therefore I'm willing to look the other way when 'Indian Magic' jettisons most of its scab-flecked leaves in late summer, only to reveal one of the most visually stunning fruit displays in all of *Malus*-dom (see front cover).

When the topic of fruit size and persistence comes up, crabapple detractors frequently trot out the poster child for obnoxious fruiting behavior, *Malus* 'Dolgo' (ignoring the fact that its large crimson fruits are great for making tasty preserves). But it would be disingenuous to paint all crabapples with the same brush. For example, crabapple selections like 'Jewelcole' (Red Jewel™) and 'Donald Wyman' produce bright red, extremely persistent fruit that eventually fall from the tree, but only after they've dried and shriveled to one-half their original size. Others like 'Snowdrift' and 'Bob White' drop very little fruit thanks to the work of opportunistic and grateful birds. And on those sites where fruit production of any kind is forbidden, fruitless selections 'Spring Snow' and newcomer 'Jarmin' (Marilee®) are viable options.



The bright red fruit of 'Donald Wyman' last through the winter.



The bite-sized orange fruit of 'Snowdrift' attract birds.

NANCY ROSE

The form of weeping crabapple 'Red Jade' outlined in snow.

JEFF ILES

The pinkish-red flowers of 'Prairifire' crabapple.

What about weeping crabapples? Real or imagined, several barriers stand in the way of using weeping trees in the landscape. For starters, consider the word "weeping." Who wants a sad landscape? Secondly, trees like weeping willow and weeping mulberry have, albeit unfairly, caused many weekend gardeners to be wary of any plant with cascading branches. Finally, and perhaps most importantly, weeping trees can be very difficult to integrate into the landscape. They vie for attention when used in groupings and look awkward and forlorn if used as a solitary specimen in the middle of a large lawn. And sticking one smack dab in the center of that unnatural-looking berm in your front yard isn't the answer either. But when classy, weeping crabapples like 'Louisa' and 'Huber' (Royal Fountain®) come along, we are obliged to find them a prime location in the landscape where they can be viewed and appreciated at any time of day and throughout the year, especially during the winter months. Positioning a weeper at the corner of a home, near a water feature, atop a terrace, or at the end of a shrub border will gain approving looks from visitors and neighbors alike.

Finally, consider a crabapple's ability to stop you in your tracks as you stroll through the landscape. If you've ever seen 'Prairifire' awash in bright pinkish-red flowers, 'Doubloons' sporting a bumper crop of golden-yellow fruit, the handsome purple cutleaf foliage of 'JFS-KW5' (Royal Raindrops®), or the memorable silhouette of weeping 'Red Jade' encased in a glittering mantle of ice, well, you know what I mean.

Still, there are some who can't be convinced crabapples are anything but disease-prone, messy trees. And in all honesty, this anti-crabapple mindset is probably a good thing. I mean, what kind of crazy world would it be if everyone began planting crabapples? See you at the garden center.

NANCY ROSE

Delicate pink flowers flow along the weeping branches of 'Louisa'.

Resources

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Malus at the Arnold Arboretum: An Ongoing Legacy

Michael S. Dosmann

NANCY ROSE

Malus in bloom on Peters Hill, the Arnold Arboretum, May 2008.

In his book *Flowering Crabapples: The Genus* Malus, the late Father John Fiala (1994) states that "no horticultural institution did as much for introducing and discovering new species, varieties, or special clones [of *Malus*] as did the Arnold Arboretum." Those are humbling words coming from such an authority as Father John. As I considered his accolade, I asked myself: What were the drivers that made this all possible?

No doubt there were a number of factors involved in making the Arnold Arboretum "the 'mother arboretum' for flowering crabapples" (Fiala 1994). Timing played a critical role in the initial development of the crabapple collection as well as its ongoing use and development. The Arboretum's founding in 1872 and early rapid expansion of collections coincided with vigorous plant exploration efforts around the world. With respect to *Malus,* countless taxa new to science were collected from the wild and described, while many others new to North America were introduced from cultivation elsewhere (primarily Europe). Additional introductions of taxa from varying parts of their native ranges ensured that a high degree of genetic variation was present.

Simply having a diverse and sizeable collection of crabapples does not necessarily make it significant, however. The collection's active use in science throughout its existence put it on the map. Early on, the *Malus* collection was notably used in the study of taxonomy—the description of new species and their classification. This was followed by the collection's incorporation into better understanding genetics and cytology, as well as physiology. The collection proved to be of value to applied horticulture as well. Following World War II, as the demand for greater diversity of high-quality landscape plants increased, the products of these plant-breeding efforts (novel hybrids and cultivars) were grown and evaluated at the Arboretum.

Development and scientific use of the collection was made possible by a number of prominent Arboretum personalities. Charles S.

Famed plant explorer Joseph F. Rock made this image of *Malus transitoria* on an expedition in Kansu (Gansu) province, China, on October 21, 1926.

Sargent, first director of the Arboretum, knew the research value of a well-documented collection and ensured that the initial development of the Arboretum, including its growing repository of apples and crabapples, would get off on the right foot. He also recognized that Rosaceae was indeed too large a family to occupy its allotted space—the hillside currently known as State Lab Slope near the Forest Hills Gate—which was dictated by the Arboretum's design based on the Bentham and Hooker sequence of plant families. And so, at the end of the nineteenth century, he designated large expanses on Peters Hill for the cultivation of *Pyrus*, his beloved *Crataegus*, and of course *Malus*. The expansion provided much relief, as numerous new species, hybrids, and cultivars were rapidly being introduced and needed space. Sargent himself collected and introduced new *Malus*, including the low-growing *M. sargentii* and the lesser-known but highly ornamental *M. tschonoskii*, both from his 1892 trip to Japan. Amazingly, the original specimens of these two species, now nearly 120 years old, still grow near the Bradley Rosaceous Collection and represent the Arboretum's oldest *Malus* accessions.

Ernest H. Wilson also played the role of explorer and introducer. *Plantae Wilsonianae* credits Wilson with collecting from some 16 *Malus* species during his travels in China, several of which were taxa new to science. Perhaps the best of these is *Malus hupehensis*, the picturesque small tree with a vase-shaped habit that Wilson made numerous collections of during both his Veitch and Arboretum expeditions. In describing its merits, Wilson (in Sargent 1913–1917) notes that "it is very beautiful in spring when covered with light pink flowers, and resembles at this time a flowering cherry rather than an apple tree; the effect of the flowers is heightened by the purple calyx and the purplish tints of the unfolding leaves."

Alfred Rehder, Arboretum taxonomist, may not have collected and introduced material from the wild, but he certainly applied his shrewd skills of observation and classification in describing and naming scores of the new *Malus*

ARNOLD ARBORETUM ARCHIVES

Malus floribunda **on Peters Hill, photo by Ralph W. Curtis, May 10, 1922.**

The lovely pink flowers of *Malus hupehensis.*


MICHAEL DOSMANN

One of the original *Malus* 'Mary Potter' (181-52-B), planted in 1952.

species and countless infraspecific taxa and hybrids. Hybrids within *Malus* are quite common, and as the Arboretum's collection grew and diversified, genes began to mix, hybrids arose, and more discoveries were made.


ARNOLD ARBORETUM ARCHIVES

In this 1959 photo by Heman Howard, Karl Sax is seen with a grafted dwarf apple tree, one of his many research interests at the Arboretum.

Perhaps the most ardent scientific user of this botanical petri dish was Karl Sax, former Arboretum director and research scientist at the Bussey Institute. Through the course of much of his Arboretum career, he integrated the Arboretum's *Malus* collection into a wide array of studies ranging from polyploidy and apomixis (Sax 1959) to plant physiology (Sax 1957). A byproduct of his many cytology and breeding experiments was an abundance of hybrids, from which Sax was able to evaluate and select a number of crabapple cultivars (Sax 1955). Four prominent ones are 'Blanche Ames', 'Henrietta Crosby', 'Henry F. du Pont', and 'Mary Potter'. The latter is perhaps his finest introduction and a personal favorite of mine. 'Mary Potter'—a cross between *M. sargentii* 'Rosea' and *M.* x *atrosanguinea*—is low-growing yet spreading, producing an abundance of single white flowers in the spring and bright red fruit in the autumn. Making the story all the more interesting is that it was named after the daughter of C. S. Sargent, and has the Sargent crabapple as a parent.

A *Malus* Mystery

Old, robust collections like the Arnold's are always full of new surprises. An interesting story concerns two unusual trees growing on Peters Hill, AA 691-52-A and B. While a Putnam Fellow in the spring of 2001, I became enamored by their wide-spreading, low-branching form; 691-52-B, the slightly larger of the two, stands 18 feet (5.5 meters) tall and 33 feet (10.1 meters) wide. The leaves and flowers are borne in dense, tight clusters throughout the canopy, giving the two specimens an unusual cloudlike appearance. The flower buds are magenta at first, and then transition into light pink before they open into creamy white blooms. The tag read simply "*Malus* sp." so I figured the trail was cold and that nothing more could be found about these plants.

However, hidden away in the records was the note: Sax 7841. "Sax Numbers," as these were known, were remnants of Karl Sax's own accessioning system at the Bussey Institute and referenced his research plants or crosses (this one being the 78th plant or cross of 1941). But unfortunately, no additional documentation had ever been found that explained the numbers further, such as source of material, what the parentage had been if it was a cross, or what the understock or scions may have been in one of his experiments. Another seeming dead end, I gave up on pursuit of this additional information.


NANCY ROSE

The mystery crabapple: *Malus* 691-52-A.

Nearly a year later, though, while rummaging through the archives, I stumbled upon an unknown notebook of Sax's that turned out to be his master list of hybrids and experimental units. With this fortunate find, I was able to identify not only these two plants but also a great number of other hybrid *Malus*, *Forsythia*, *Prunus* and other genera. It turned out that the duo in question were hybrids that Sax had made between *M. lancifolia* and *M. sylvestris*. Although I do not know if it was his original intent when making the cross, he used these hybrids in a rootstock experiment, possibly to examine any potential dwarfing effects rootstocks can have upon the scion above. Two seedlings of Sax 7841 were the ungrafted individuals I was struck by (691-52-A and B), while 780-52-A and D, located westward and up the hill a bit, were grafted plants that had Sax 7841 as the understock and an unknown wild apple as the scion (his notebook did not provide that detail, alas). Although Sax's cross yielded an unusual plant with ornamental habit, it would be premature to introduce it as a cultivar without further evaluation. And so, in 2007, Arboretum propagator Jack Alexander grafted budwood from both plants of 691-52 onto numerous seedlings of *Malus* 'Antonovka'. Soon these trees will be planted and further evaluated for potential selection and introduction.

While Sax may have been the creator of many of the cultivars, it was Arboretum horticulturist Donald Wyman who was their biggest promoter. He lauded their merits throughout the pages of *Arnoldia* and in his books, and advocated for their use in his lectures and correspondence. And, like Sargent before him, Wyman tapped his extensive global horticultural network to distribute Arboretum selections as well as acquire new taxa to grow and evaluate. In honor of Wyman's dedication to crabapples, the Arboretum introduced *Malus* 'Donald Wyman' in 1970 to honor him in his retirement. A fantastic selection, it is appreciated for its abundant white flowers in the spring, relatively high disease resistance, and very long-lasting display of brilliant red fruit from autumn through winter. Interestingly, this tree was actually a spontaneous seedling that was first recorded growing on Peters Hill on March 20, 1950. Due to its aesthetic appeal, it was later accessioned and then selected and introduced as the cultivar known today; the original tree still stands. It is ironic that, despite the great efforts of breeding and selection made over the years, the Arboretum's most important crabapple introduction to date must be chalked up purely to serendipity.

MICHAEL DOSMANN

MICHAEL DOSMANN

The original specimen of 'Donald Wyman' (seen here in spring bloom and fall fruit) still stands on Peters Hill.

Although the period from Sargent to Wyman may have been known as the "Golden Era for Crabapples" at the Arboretum, work in the collection did not end when Wyman retired. As the Arboretum shifted the focus of its collections policy towards acquisitions of known wild origin in the 1970s and 1980s, novel germplasm from Asia again crossed the threshold. For example, the 1980 Sino-American Botanical Expedition yielded several fascinating collections, including an unusual southern provenance of *M. baccata*, the Siberian crab, found in Hubei province. In addition to its unusual collection site, this collection (SABE #1298) produces flowers and fruits borne on particularly long pedicels (Spongberg 1991). An amazing trio of this accession, AA 1843-80-D, H, and I, each with outstanding spiral-grained bark,


MICHAEL DOSMANN

This trio of *Malus baccata* display their distinctive spiral-grained bark in the Arboretum's Bradley Rosaceous Collection.

can be found in the Bradley Rosaceous Collection. Other collections of *M. hupehensis* and *M. halliana* were made on this momentous expedition as well, significantly increasing the genetic diversity of these species in cultivation. The Arboretum collection continues to undergo development. Recently, we have acquired a number of wild-collected *M. sieversii,* the progenitor of the cultivated apple found growing in Kazakhstan and neighboring countries.

With respect to the enhancement of fruiting genotypes, the Arboretum's collection played a noteworthy role, even if it was indirect. Apple scab is a serious fungal disease that damages not just the leaves of trees but also fruits, causing serious economic losses in apple orchards. Resistance can be conferred by the presence of the *V_f* gene, whose original source came from *Malus floribunda* selection 821 growing at the University of Illinois. This clone, the most frequently used source for scab resistance in the world (Koller et al. 1994), arose from seed sent from the Arboretum in 1908 to C. S. Crandall, a geneticist at the University of Illinois who was studying inheritance patterns in *Malus.* However, it was not until the 1940s that the initial crosses were evaluated for disease resistance, and it has only been in the last 30 years that high-yielding cultivars have been introduced through the PRI (Purdue-Rutgers-Illinois) Apple Breeding Program, the most important just in the last few years (Janick 2006). I like this story for a number of reasons. It demonstrates how important it is for the Arboretum to distribute material (plants, seeds, cuttings, tissue, etc.) to researchers to enable their work. It also illustrates the importance of prudence and patience when working with trees—in this case, it has taken nearly 100 years since the original shipment from the Arboretum for the most meaningful dividends in research (in this case superior apple cultivars through one breeding program) to be realized.

Currently, the Arboretum's living collection of *Malus* comprises 455 accessioned plants (about 3% of the total collection), representing 173 unique taxa, 104 of which are cultivars. Development is constant: old lineages of high value are maintained through vegetative propagation, discretionary accessions are disposed of, and new germplasm is obtained. Recent and future renovations on Peters Hill and the Bradley Rosaceous Collection provide wonderful opportunities to grow novel material of both wild and cultivated origin. At the species level, the goal is to possess two to three wild provenances; for cultivars, we will continue to trial new introductions of ornamental selections and will also begin to feature several selections of eating apples. And, of course, the collection will continue to hold many old and historically important selections, including those introduced by the Arboretum.

NANCY ROSE

Malus 'Dorothea'.

Crabapple Cultivars Introduced by the Arnold Arboretum

'Barbara Ann'

'Dorothea'

'Henrietta Crosby'

'Henry F. Dupont'

'Katherine'

'Pink Pearl'

'Blanche Ames'

'Bob White'

'Donald Wyman'

'Mary Potter'

'Prince Georges'

M. baccata 'Columnaris'

M. baccata 'Jackii'

M. ioensis 'Palmeri'

M. x *robusta* 'Erecta'

M. sargentii 'Rosea'

M. x *zumi* 'Calocarpa'

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In the Footsteps of Father David

Cédric Basset

Armand David (1826–1900), famously known as "Father David," is well known by those passionate about plants. Indeed, many plants carry his name, such as *Davidia* and *Acer davidii.* Though best known for his plant discoveries, one cannot mention this great figure without also mentioning the famous giant panda that he discovered in 1869 near Baoxing (previously Moupin) in the Sichuan province of China.

During our expedition to Sichuan in May, 2007, we followed the same paths that Father Armand David took during the second half of the nineteenth century. These regions—with their extraordinarily rich flora and fauna—are fortunately still preserved, no doubt in part because they remain very difficult to access.

A Few Notes from Father David

Upon arriving in Moupin, Armand David wrote: *"The land of steep mountains is, despite the loggers and farmers, abundantly forested with fir trees and cedars up to 3,000 m… The lanceolate pine and the narrow-leaved pine, as well as the alder of Setchuan, thrive up to 2,000 m. The rhododendrons are particularly abundant."* It

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This flowering *Rhododendron* was part of the extreme botanical richness we admired in the narrow valley of Pujigou, located south of the nature reserve of Fengtong.

should be noted that there are no cedars (*Cedrus*) in this region; Father David probably uses this term to designate other conifers with a similar horizontally spreading form. The lanceolate pine is certainly his designation for *Cunninghamia lanceolata.*

At that time, Moupin (now known as Baoxing) was still part of Tibet. And Armand David wrote: *"Long closed to the Chinese, the principality now tolerates their growing number."* That was a different era, indeed.

On March 23, 1869, having just discovered the giant panda (*Ailuropoda melanoleuca*) he writes: *"The young bear is entirely white, except for his four limbs, his ears, and the area around his eyes which are a deep black. Thus, we have here a new species of Ursidae that is very remarkable not only because of its color but also because of the hairiness under its paws."*

Later, he writes concerning his botanizing: *"The large rhododendrons are flowering, and I can already distinguish at least seven distinct species. I also found, in the middle of a wet forest, a magnificent magnolia with large purplish flowers and with no leaves yet."* This may be *Magnolia liliiflora,* naturally present in this region.

Cunninghamia lanceolata **is a large conifer in the cypress family (Cupressaceae) that can reach 50 meters (164 feet) in height. It is present in the landscape of the Chinese provinces explored by Father Armand David.**

Baoxing, Town of the Panda

Nowadays, the little town of Baoxing pays homage to Father David with a statue of him and with another that celebrates his discovery of the panda. The balustrades along the river are engraved with representations of the numerous species of plants and animals that he discovered during his sojourn in the region.

According to numerous local officials, Armand David's discovery over 130 years ago confers on Baoxing the status of "cradle of the giant panda." And yet, Baoxing remains infrequently visited by tourists. Westerners are rare, since the town is located on a road little used by tourists. The roads that connect Chengdu to Tibet through Kangding and Litang, or through Wolong, pass to the south and north of Baoxing, respectively, while the north–south road that connects Rilong to Ya'an through Baoxing is poorly travelled.

There are several explanations for this lack of tourist traffic. The road linking Rilong to Ya'an is not always in a good state. It is long and winding, and the lack of bus service forces one to use a taxi. There are few possible stops along the road. Our stop in the small town of Yanjingping was an adventure: no real hotel, only one very dirty house, and one building

ARNOLD ARBORETUM ARCHIVES

An Extraordinary Discoverer of Life

Armand David was born September 7, 1826, in the village of Espelette in southwestern France. On November 4, 1848, he joined the Lazarist order in Paris where he studied for several years. He then traveled to Italy to study medicine, zoology, and botany. On July 5, 1862, he arrived in Peking where he lived for the following twelve years. During those years, he carried out three expeditions to western China. After falling sick during the third expedition, he returned to France in 1874. During his life in China, he visited Inner Mongolia, Shanghai, the Sichuan provinces, and Hubei and Jiangxi, combining his missionary work with his scientific research. From March 1, 1869, until 1872, he worked in Moupin (now known as Baoxing) in Sichuan. During his travels in China, Armand David collected 13,000 specimens including 189 new plant and animal species, among these the handkerchief (or dove) tree (*Davidia involucrata*), the butterfly bush (*Buddleja davidii*), *Lilium davidii*, *Populus davidiana*, as well as thirteen species of rhododendrons, three magnolias, four firs, and four oaks.

where we found a room with no bathroom facilities. In the only restaurant in town, we involuntarily attracted a crowd and became, for the duration of our dinner, the main attraction. Baoxing, on the contrary, turned out to be a quiet small town, ideal for an enjoyable stop. There we stayed in a comfortable hotel where the rooms were very clean.

The Forgotten Valley and Pujigou

Baoxing is located to the south of the nature reserve of Fengtong. This reserve covers 40,000 hectares (98,842 acres), with 13 percent of the area serving as habitat for the panda. The town proudly advertises the region and its natural marvels—virgin forests, waterfalls, forests of *Osmanthus*, panoramas—but public transportation, as often in China, is non-existent. One must hire a vehicle and driver (fairly easily done at the train station) and communicate to the driver that he must wait all day or return to a meeting point after several days. Otherwise, in the small villages, one would not be sure of finding a vehicle available for returning to town.

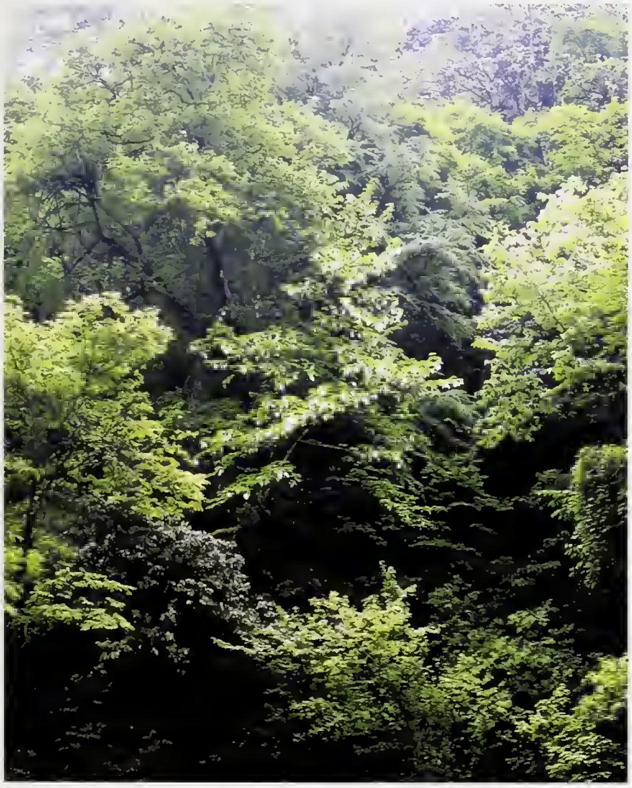
We decided to enter the nature reserve by an alternative route, by taking the road that leaves from the northwest of Baoxing and winds to its final destination, the village of Pujigou. The road, paved at its start, rapidly gave way to a narrow dirt path where we had perilous crossings with the trucks from a nearby quarry. To our surprise, after two and a half hours of driving, our driver stopped before a dilapidated wooden bridge and told us that we had to continue on foot.

He told us that Pujigou was located about an hour's walk further. We took five hours, since we walked very slowly at first, our botanical passion ignited as we marveled at discovering an interesting plant with each step. The flora in this infrequently traveled area offers a rare diversity, the very acidic soil being favorable to the growth of many plants of the Ericaceae and the climate allowing amazing sub-tropical species to flourish.

We arrived at an old, abandoned building in the middle of the forest where two men and one woman lived without electricity. The reception was icy at this abandoned and empty inn. We were in Pujigou. It is not really a village, but rather the remains of what must have previously been a remote mountain refuge. Deciding to flee this place, we turned around and went on to find a village where we were hosted by a local resident.

The Fengtong Reserve

In all of our previous trips to China we had never found such a wild valley as at the Fengtong Reserve. Unlike more accessible nature reserves such as Wolong, here at Fengtong there was no road, no cars or buses, only a small path. The valley is narrow, with steep slopes covered with dense vegetation that benefits from the very humid air. From a botanical perspective, it is a real treat.



Davidia involucrata (center) bloomed among the dense vegetation in this narrow valley in the Fengtong Reserve.

The orchid _Calanthe tricarinata_ grows about 30 centimeters (about 12 inches) tall. It enjoys semi-shaded areas and a humid climate.

The superb striped bells of _Enkianthus deflexus_.

All along the trail, magnificent handkerchief trees (the famous *Davidia involucrata*, dedicated to Father David) in full bloom hung over us. The edge of the path was full of flowering *Disporum bodinieri* (a member of Convallariaceae) and a somewhat rare *Paris*, *Paris fargesii*. In the nooks of dead tree trunks and on rocks, beautiful orchids—*Calanthe tricarinata* and *Pleione limprichtii*—bloomed abundantly. Above our heads we saw two beautiful shrubs, *Dipelta yunnanensis* of the honeysuckle family (Caprifoliaceae) and *Enkianthus deflexus* of the family of the rhododendrons (Ericaceae). The giant dogwoods (*Cornus controversa*) spread their tiered silhouettes above the shrubs.

***Cornus controversa* displays its elegant horizontal branching habit.**

Some Rare Finds

One great surprise was finding dozens of plants of one of the most spectacular hornbeams, *Carpinus fangiana*. I had wanted to see it for a long time and had already searched for it, notably at Mount Emei (Emei Shan). This tree is surprising for its large leaves (longer than 20 centimeters [7.9 inches]) and catkins that can reach 50 centimeters (19.7 inches) long.

Several species of viburnum (among these *Viburnum brevitubum*) carried their long, white tubular inflorescences in the manner of the viburnum of China, *Viburnum chingii*. We met more frequently another little shrub with lots of flowers: *Deutzia glomeruliflora*.

In this gorgeous reserve, another seasonal spectacle was provided by climbing plants of the Lardizabalaceae: *Holboellia* and *Akebia*. Certain stems, several meters tall, were covered with flowers exuding a sublime scent. A few plants of *Akebia trifoliata* revealed flowers that were almost black. A little higher, *Sinofranchetia chinensis*, belonging to the same family, was reaching even farther up into the trees.

The trail, although inaccessible to cars, was very good for walking. Certain signs showed that it was previously accessible to vehicles. The reserve is home to the giant pandas, and large stands of bamboo of the genus *Drepanostachyum* bordered the trail. We also saw a beautiful, large *Yushania* on which climbed *Codonopsis tangshen* (in Campanulaceae), not in flower.

Remembering Father David

At the forest's edge and along paths on shady rocks, several species reminded us of Father David:

- *Epimedium davidii*, a small epimedium (Berberidaceae) with beautiful four-pronged yellow flowers.
- *Acer davidii*, David's maple (Sapindaceae), with its bark finely striped with white.
- *Corydalis davidii* (Fumariaceae) with its pretty yellow flowers. Much rarer is the impressive *Corydalis anthriscifolia*, a large plant with long purple inflorescences of which we saw only one specimen.

In another small, narrow valley, we observed large arisaemas in flower with enormous leaves

The superb *Carpinus fangiana* growing in the dense forests of Pujigou.

Viburnum brevitubum growing in the cracks of rocks in the Fengtong Reserve.

Holboellia sp., a perennial vine with strongly perfumed flowers.

Yet another plant named in honor of Father David, the lovely *Epimedium davidii.*

composed of three leaflets. This was *Arisaema dilatatum,* a little-known species distributed from western Sichuan to Bhutan.

We also were very surprised by the diversity of maple species in this valley. We admired the very rare *Acer sutchuenense,* a small tree of 5 to 8 meters (16.4 to 26.2 feet) high with trifoliate, denticulate leaves.

The Big Surprise

The exploration of this fantastic valley ended in an exciting discovery—finding plants of the famous and rare hellebore of Tibet (*Helleborus thibetanus*). This species (in Ranunculaceae) lives in isolation, as the next closest hellebore species grow more than 5,000 kilometers (3,100 miles) to the west. This hellebore is doubtless the most delicate of its type, with sepals much more finely-textured than the other species. Its flowers vary from pinkish-white to dark pink, often with darker pink veins.

Helleborus thibetanus was described by Franchet in 1885 from specimens collected in

1869 by Armand David at Baoxing in Sichuan. The same year, Beresowski collected specimens in the province of Gansu that were described by Maximowicz in 1890 under the name *Helleborus chinensis*, a name now synonymized under *H. thibetanus*.

Tibetan hellebore's introduction to Europe is relatively recent. In 1991, seeds were sent from China by Professor Kao Pao-chung of the Chengdu Institute of Botany. They had been collected from Sichuan, near Baoxing, on Dengchigow mountain at an elevation of 2,300 meters (7,500 feet).

Among the long list of other species that we observed, we should mention *Cotoneaster moupinensis*, several superb dark *Cardamine* along the creeks, several *Clematis*, several *Euonymus*, a beautiful *Magnolia* that was not

The rare ***Helleborus thibetanus*** **bears delicately veined pink flowers.**

flowering, several honeysuckles (*Lonicera*), one *Sorbus* with simple leaves, and several plums (*Prunus* spp.).

The very strange-looking *Arisaema dilatatum*.

A Good Inspiration

Father David chose well in coming to this mountainous region. The diversity of its flora and fauna is fascinating and important. Efforts to protect the panda and the creation of reserves have allowed the preservation of very species-rich valleys. To travel in this area, one must temporarily do without some comforts, but it is truly worth it, especially since Baoxing has several good hotels.

This region is representative of western Sichuan on the road to Tibet. In addition to Baoxing, one should stop in Kangding, Ganjia Caoyuan, Garze, or also at Mugue Lake to discover fabulous landscapes and a very diverse natural world.

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Translated from French by Elizabeth H. Zacharias, Ph.D., and Ian C. Bourg, Ph.D.

BOOK EXCERPT:

Between Earth and Sky: Our Intimate Connections to Trees

Nalini M. Nadkarni. University of California Press, Berkeley and Los Angles, California. 2008. 322 pages. ISBN 978-0-520-24856-4

Editor's Note: **Dr. Nalini Nadkarni is a noted expert on the ecology of forest canopies in both tropical and temperate regions. Her innovative research has led to greater understanding of forest canopy ecology and forest ecosystem ecology. In this book, Nadkarni steps back from pure science and instead explores the profound connections between humans and trees. The book's structure is based on a creative modification of psychologist Abraham Maslow's pyramidal hierarchy of human needs. Here, the pyramid represents levels showing how human needs are met by trees, from the basic levels of physical needs like food and shelter, mid levels including imagination, language, and connections to time, and ultimately to the apical levels of spirituality and mindfulness. The following are brief excerpts from three chapters.**

GOODS AND SERVICES

Although humans now rely on ships and airplanes made of metal for long-distance transport, trees still figure into the regional and local transportation of our commodities. In 2000, for example, well over half of the $1.7 trillion worth of goods that entered and left the United States used some form of solid-wood packing material, such as pallets and crates. In 2001, an estimated two billion pallets were in use in the United States—six for every American. Over half of these are designed to make just one trip, and pallets as a whole average just 1.7 trips. Only about 10 percent are recycled, ground up and used as landscaping mulch, animal bedding, or core material for particle board. The wood in the pallets that are discarded each year is enough to frame 300,000 average-sized houses. Each year, too, 500 million more pallets are made, consuming trees on the equivalent of 18,000 acres.

Our global reliance on pallets also introduces nonnative pests. One is the Asian longhorned beetle, an "exotic" pest that has threatened North American hardwood trees such as maple, elm, birch, poplar, and willow since 1996. The clue that these large beetles arrived in "Trojan pallets" was that outbreaks were concentrated near warehouses in New York, New Jersey, and Chicago, which contain pallets from China and Korea, where the beetles are native. Since then, infested pallets have been intercepted by vigilant entomologists in many North American cities, and so far, serious outbreaks have been contained. Europe, meanwhile, is suffering from an invasion of the pinewood nematode, thanks to products received from the United States, China, and Japan. Because of such threats, many export companies have begun to use metal or plastic pallets. These in turn create other problems, as those materials are not as easily recycled.

PLAY AND IMAGINATION
DREAMING ALOFT

To many climbers, the ultimate experience is spending a night high in the treetops. There is something about sleeping in the forest—whether on the ground or in the trees—that brings us as close as we can get to nature.

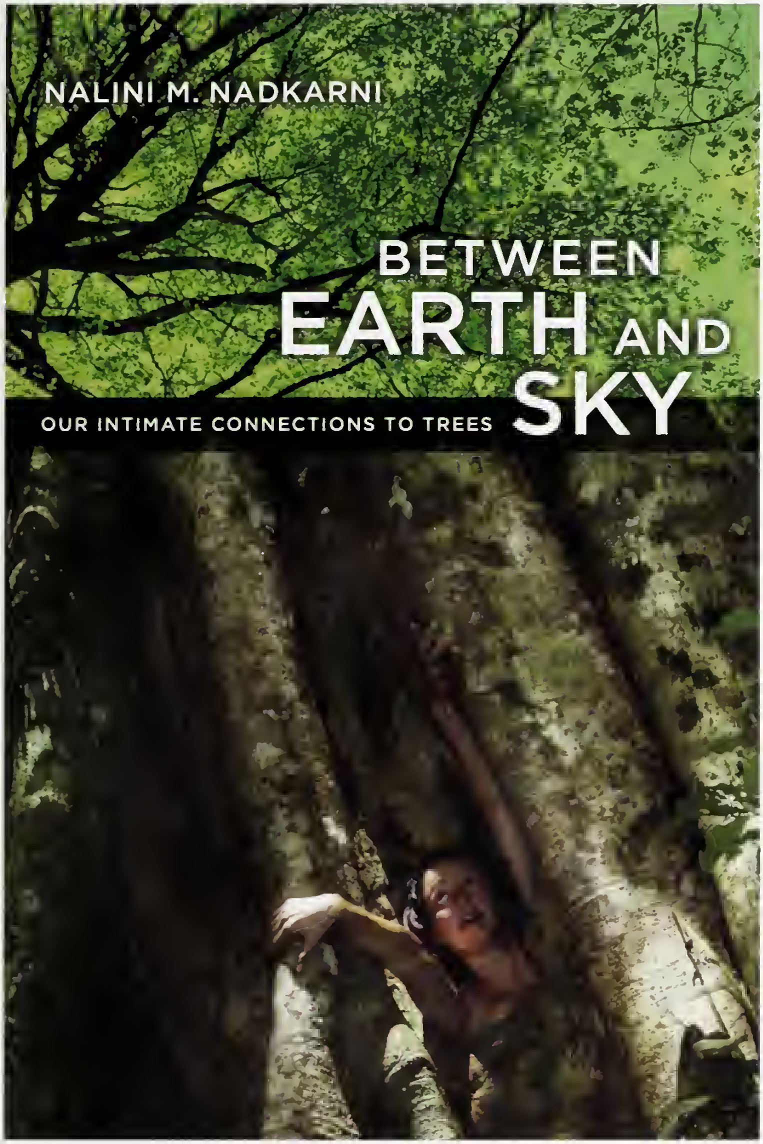
My first overnight experience suspended in a hammock between branches of a giant tropical rainforest tree remains vivid in my memory even thirty years later. I climbed into the canopy as the sun set, the darkening understory giving way to the lighter environment of the canopy—though that, too, gradually became part of the jungle night. Bird songs gradually yielded to the buzzing, whirring, creaking calls of insects, which grew louder both below and above me, a sort of stereo effect I had never heard before. I curled up on my hanging cot, water bottle and a bag of snacks tied to an auxiliary cord, my harness and rope giving me a sense of security as the spookiness of being two hundred feet above the ground crept into me. At some point during the night, an anteater rambled over to my perch, in pursuit not of a dormant human but rather of the steady stream of leaf-cutter ants that were harvesting chunks of leaves from the trees and walking them along the branch highways down to their underground nests. On seeing me, the collie-sized mammal seemed as startled as I had been. But we looked at each other for a long moment without fear, two arboreal animals in a high place on a dark night.

Since that time, I have spent many nights aloft. What has surprised me is not the "otherness" of the canopy night compared to where we ground-bound humans normally sleep, but rather how homey and comfortable it seems up there with darkness stretching out in three dimensions. We were raised with the classic lullaby, "Rock-a-bye baby in the treetops," with its inevitable and sobering conclusion: "and down will come baby, cradle and all." And there are noxious insects and poisonous reptiles somewhere up there. But during those nights I spent on my canopy cot, swaying slightly in the wind one hundred feet above the ground, I couldn't have felt safer and more ready for sleep, lulled by my nocturnal companions above, below, and around me.

CONNECTIONS TO TIME

Trees express time with a precision and beauty that are unmatched in nature. Changes in their foliage mark the passage of Earth's seasons, while the incremental growth in their rings mark Earth's years. Nothing more effectively indicates seasonal transitions than the tender green of the emerging buds of spring, the rich, deep greens of summer, the multicolored leaves of autumn, or the delicate filigree of snow on tiny twigs after a winter storm. We are inspired by trees' relationships to time: the great age they can attain and the fierce disturbances they can endure. When we walk along the winding paths of a cemetery, we pass beneath the trees that have dwelt there far longer than their interred neighbors, giving us a comforting sense of continuity.

Measuring the age of trees in tropical forests has been a perennial problem for ecologists. Because in many places favorable growth conditions occur year-round, many trees in the tropics are constantly growing and so have no rings at all. Even trees that do undergo seasonal growth, such as those in habitats where rainfall is concentrated into a few months of the year, have unreliable rings because they can jump into a growth mode in response to even small inputs of out-of-season rainfall. The tropical dendro-



chronologist, therefore, must turn to other methods to determine a tree's age.

One surprisingly useful tool for tree dating emerged through the development of atomic weaponry. During the early era of nuclear testing, atomic devices were detonated in the atmosphere. The radioisotopes ejected from these explosions spread worldwide, forming a thin, weakly radioactive blanket over the earth. Some of these radioisotopes mimic naturally occurring elements so closely that many plants and animals cannot distinguish them. Trees take them up and incorporate them into their cells, along with their regular nutrients. Radioactive strontium, for example, mimics calcium, a nutrient that plants use to build new cell walls, much as animals use calcium to build bones. In 1954, trace amounts of radioactive strontium generated from bomb tests wafted through the air, dissolved in rain, entered the water cycle, were absorbed by roots, and then were incorporated into the living tissues of trees. This resulted in a short-lived but distinctive radioactive signal that has been held in the tissues of all of the trees living in the world at that time. Now, half a century later, scientists extract pieces of wood from tropical trees and note where in the cross-section of the trunk the "1954 bookmark" of radiation occurred. This allows scientists to measure how much each tree has grown since that time. Although the results cannot be extrapolated to determine how old a tree is, they do provide the dendrochronologist with an exciting tool to compare the rates of growth (from 1954 to the present) of individual trees and different species of trees that lack reliable rings. By revealing relative growth rates, this approach gives scientists a better understanding of population dynamics within forests.

Autumn's Harbinger: *Acer rubrum* 'Schlesingeri'

Michael S. Dosmann

Autumn is my favorite time of year, and during the dog days of late summer I particularly look forward to the cooler, crisper, colorful months to come. That's why I am delighted when, on some sultry August afternoon, I notice that our *Acer rubrum* 'Schlesingeri' has begun to express the first hints of leaf color at the Arboretum. In most years, the green foliage of this early-coloring red maple shades to bronze by mid August, and by early September the entire canopy is ablaze in carmine red. The colorful display usually holds into October.

The precocious and stunning autumn coloration of this selection first caught the eye of Arboretum director Charles S. Sargent in the late 1800s. The original tree grew at the home of Sargent's neighbor, Mr. Barthold Schlesinger, in Brookline, Massachusetts. On February 13, 1888, budwood from this tree arrived at the Arboretum and, upon grafting, became accession 3256-A. It was planted along Meadow Road across from the Hunnewell Building, where it remains to this day.

Curiously, this cultivar's introduction to the ornamental scene occurred not in North America but in Europe. Sargent had shared it with the world-famous Späth Nursery in Berlin, which first made it commercially available in their 1896–1897 catalog. During World War II, the nursery dissolved, no doubt limiting the supply of this sought-after clone. In 1951, the Arboretum distributed plants to some 25 cooperating nurseries as a means of promoting the cultivar and increasing supply. In his description of the tree and this distribution program, Donald Wyman (1956) noted the efforts made to learn if the precocious fall color trait was truly genotypic or just a function of environment: "... scions from this variety were grafted on seedling red maples, but both the scion and the understock were allowed to grow. In the fall, it was clearly evident that the variety *schlesingeri* ['Schlesingeri'] would produce autumn color several weeks before the seedling understock on which it was growing, regardless of where it was planted."

Unfortunately this cultivar is now often misidentified, so the *Acer rubrum* 'Schlesingeri' that you purchase at the local nursery may not be true-to-type. This has even happened at the Arboretum. In the early 1980s, three trees labeled as 'Schlesingeri' were donated by a large, reputable, national nursery. But in 1989, Arboretum horticulturist Gary Koller noted that they "do not match 3256-A ... identification (of) this cultivar is questionable." Further observations proved Koller correct and these trees were duly removed. Michael Dirr, in his *Manual of Woody Landscape Plants*, also noted that "some of the material in today's market does not appear similar to the Arnold Arboretum's fine specimen." And an interesting study on red maple cultivar coloration (Sibley et al. 1995) yields further evidence: although the trees of 'Schlesingeri' examined in the study were obtained from a reputable nursery, they developed the wrong leaf color (orange) far too late (no earlier than the 5th of October) to be true 'Schlesingeri'.

Over 120 years later, this old sentry remains in its original location. It stands 65 feet (19.8 meters) tall with a crown spread of about 60 feet (18.3 meters), and its trunk diameter (below the lowest branch) is 44.6 inches (113.3 centimeters). Red maples generally reach maturity at around 75 years of age, so it is no surprise that this individual is in decline. Recent efforts to maintain this important lineage by rooting cuttings have been a success: accession 408-91-A grows next to Faxon Pond, and scores of new cuttings are now rooting in the greenhouse. One of these new plants will eventually replace the original tree, while others will be distributed to commercial nurseries so that they, too, will have the real cultivar again.

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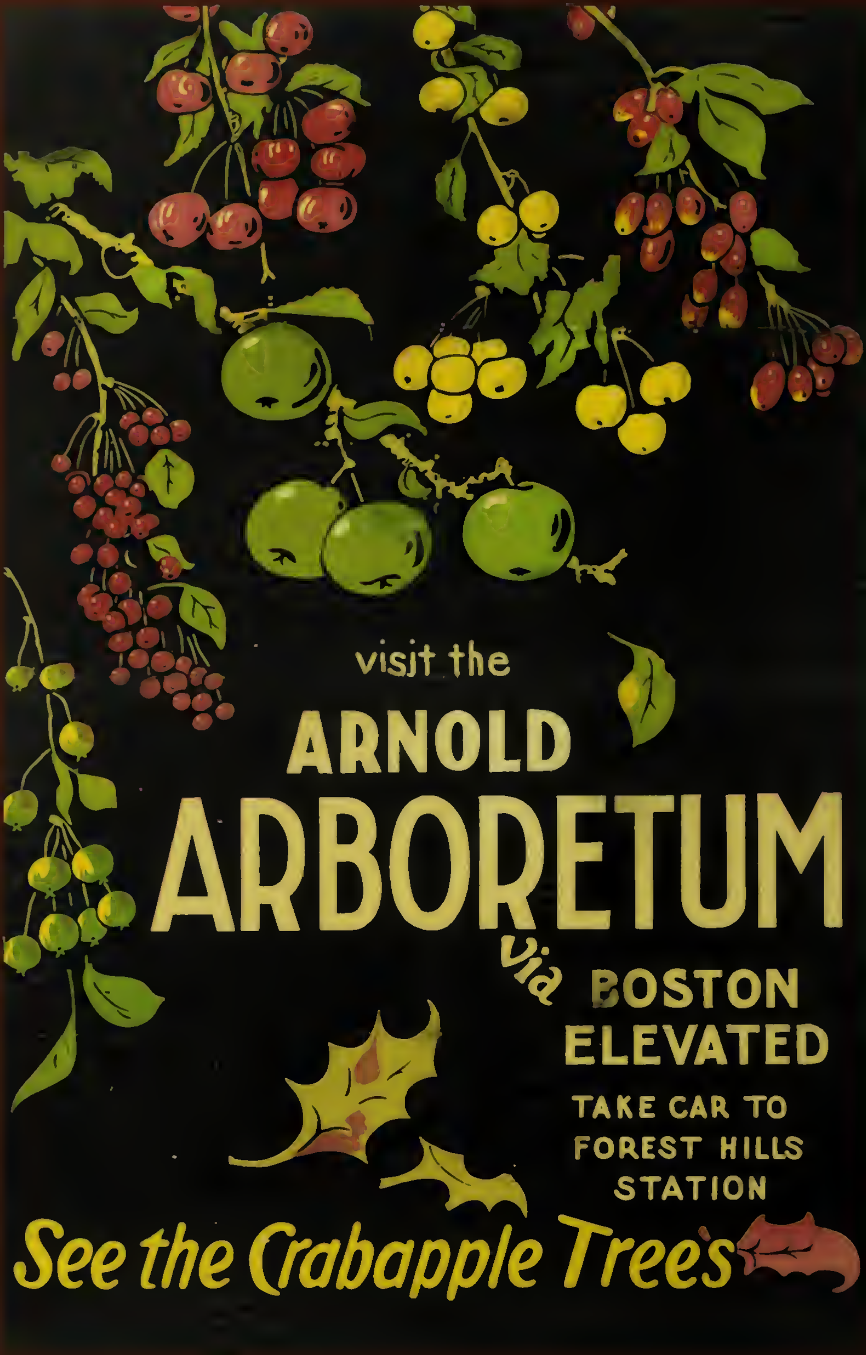
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Front cover: Black chokeberry (*Aronia melanocarpa*) is valuable as an ornamental landscape shrub and for its antioxidant-rich fruit. Photo by Nancy Rose.

Inside front cover: In their new book, *Wilson's China: A Century On*, Mark Flanagan and Tony Kirkham describe following in the footsteps of famed plant explorer E. H. Wilson. They came across these lampshade poppies (*Meconopsis integrifolia* ssp. *integrifolia*) in the same locale where Wilson first found the species a century ago. Photo by Tony Kirkham.

Inside back cover: Himalayan pine (*Pinus wallichiana*) is notable for its fine-textured, cascading foliage. Photo by Nancy Rose.

Back cover: Fruit color in *Aronia* species ranges from black to purple to bright red. Photo by Mark Brand.

An Excerpt From *Wilson's China: A Century On*

Mark Flanagan and Tony Kirkham

Editor's Note: Ernest Henry Wilson was one of the most intrepid and productive plant hunters of his era—the beginning of the twentieth century. His collecting trips to China—first for Veitch Nurseries in England and then on behalf of the Arnold Arboretum—resulted in an extraordinary stream of new plants to the West. Arboretum director Charles Sprague Sargent instructed Wilson to thoroughly document his 1907–1908 and 1910 expeditions with photographs; these striking images still reside in the Arboretum's archives.

Mark Flanagan, Keeper of the Gardens at Windsor Great Park, and Tony Kirkham, Head of the Arboretum at Kew, are modern-day plant hunters, having traveled and collected extensively in eastern Asia. Admirers of Wilson, they plotted a journey to retrace his footsteps in Sichuan, China. Using Wilson's expedition photographs as a guide, they were able to capture views of some of the very same locations and even plants that Wilson saw a century ago. Their book pays homage to Wilson and provides a fascinating "then-and-now" glimpse of China's landscape. The following is an excerpt from Chapter 3, "Mystery Towers of Danba."

Tatien-lu is a small and filthy dirty place, it boasts a large mixed population of Chinese and Tibetans. Being on the highway from Pekin to Lhasa, officials are constantly passing and re-passing. This makes it a highly important place, both politically and commercially. Although Batang, 18 days journey to the west, is the actual frontier town, Tatien-lu is really the gate of Tibet.[1]

Wilson's accurate but rather unflattering description of Kangding was penned at the conclusion of his first visit to the town in 1903. Wilson had made the journey to Kangding on the instructions of the Veitch nurseries who wished to add a very special plant, the lampshade poppy (*Meconopsis integrifolia*), to their nursery catalogue. "Messrs. Veitch despatched me on this second, and very costly, journey to the Tibetan border for the sole purpose of discovering and introducing this, the most gorgeous alpine plant extant," recorded Wilson.[2]

Kangding still has a frontier town feel about it and is inalienably a Tibetan place. It also remains a very important staging post on the road that leads westward into Tibet. This road was one of the great highways constructed during imperial times to hold the Celestial Empire together. But Chinese writ did not extend very far. Indeed the country around Kangding remained lawless and untamed until very recent times. Historically the area was known as Kham and its inhabitants, the Khampas, were much feared for their ferocity and war-like demeanor. In truth, Khampa was a collective noun as the area was home to a very diverse group of related, though distinct, peoples. For a thousand years, after the collapse of the vast Tibetan Empire in the ninth century, Kham remained unconquered and unconquerable, its peoples engaged in ceaseless internecine

The authors, Mark Flanagan (left) and Tony Kirkham (right), surrounded by prayer flags at the Ya-jia Pass.

conflict as petty warrior chieftains battled for supremacy. Banditry was an accepted means of acquiring wealth and position.

The various groups of ethnic peoples he encountered fascinated Wilson and he wrote about them extensively. His understanding was gained both first hand and through studying the work of contemporary ethnographers, though this understanding was far from exact. For example, he used the Chinese generic, and derogatory, name "Sifan" (western barbarian) to describe the tribe now identified as the Qiang, one of the 56 official ethnic peoples in China. To the enquiring Edwardian mind the alien culture and manners of the various peoples, particularly their peculiar (and supposedly immoral) sexual liaisons in which both polyandry and polygamy were commonplace, was of abiding interest. Their relative lack of sophistication also appealed to Wilson, suggesting to him a oneness with their environment that he found endearing.

The eventual subjugation of the Kham region in what the Chinese called the "peaceful liberation of Tibet" finally ended the brigandry and general lawlessness in the 1950s. Eastern Kham formally became part of Sichuan Province and Western Kham formed a large part of the Xizang Autonomous Region. Despite this the Khampas retain their individuality by virtue of their strong culture and association with their land. In travelling this country it is impossible not to be impressed by their proud bearing and independent mien and it is easy to

Finding the lampshade poppy (*Meconopsis integrifolia* subspecies *integrifolia*) was the principal objective of Wilson's second trip to China.

understand how they struck fear into the hearts of friend and foe alike. Despite the suppression of banditry, in recent years occasional acts of violence against foreigners still occur when travelers are held-up by groups of armed local men: old habits die hard.[3] Through the 1980s and 1990s the Kew expeditions to this part of China employed the services of an armed Chinese policeman, Lao Liu, as a precaution against unwanted local attention, though he never drew a weapon in anger!

Wilson's quest for the lampshade poppy was, therefore, into territory that he knew little of and amongst people with whom, at that stage, he was largely unfamiliar. Not only was the territory unfamiliar, it was built on a grand scale. The Da Xue Mountains into which Wilson was travelling, together with the neighboring ranges form part of the vast, complex Hengduan Shan, the eastern extension of the Himalaya. They were created at the same time but, due to the shearing effect involved when the landmass of India collided with the Asian continent, they incline north–south. These mountains, eroded by monsoon-swollen rivers—the Jinsha, Yalong, Dadu and Min—form an enormous convoluted mass of peaks, ridges and spurs with deep, sheer-sided valleys. The range climaxes at the summit of the mighty Gongga Shan, which at 7,556 meters is Sichuan's highest mountain by some way. Joseph Rock brought Gongga Shan to the attention of the West in 1930, when he infamously over-estimated its height, erroneously claiming it to be higher than Mount Everest.[4] Wilson would be travelling at far higher elevations and over much more demanding terrain than he had experienced in his first trip to the more modest hills and valleys of Hubei.

He was not alone, however. It is intriguing that Wilson rarely mentions any western companions in his writings, let alone provides any details of their backgrounds and occupations. This time, as he prepared to find the lampshade poppy, he was accompanied by an experienced traveler. On July 16, 1903, he started out for the mountains: "On this journey I was accompanied by Mr. Edgar of the China Inland Mission, in whom I found a delightful companion ... Leaving by the South Gate we followed the main road to Lhasa—a broad, well-paved road."[5]

[. . .]

The main road to Lhasa was a well-travelled highway but not one that Wilson would remain on for long. It quickly rises to the Zheduo Pass, which today is still the most commonly taken route into Tibet from western Sichuan. On the flanks just below this pass the lampshade poppy can be easily found and many writers have assumed that this is where Wilson gathered his first plants. But the

Zheduo Pass was not Wilson's destination; he was heading for the Ya-jia Pass, which followed an alternative and much less-used track to the south.

At first the journey was enjoyable and Wilson reveled in his surroundings: "*Our road was through lovely grassy country, with a steady rise. A wealth of many colored herbs enlivened our path,*" and, "*we continued through similar country, with a fine snow-clad peak straight in front of us and another to our left.*" Soon, however, the going became much tougher, and heavy rain fell as they reconnoitered the mountainsides close to their overnight stopping point. The altitude had a detrimental effect on his coolies and all endured a miserable night.

Our journey up to the Ya-jia Pass was rather more comfortable. The road was well surfaced right to the top, though the occasional small landslip had to be carefully negotiated by the vehicles. As Wilson suggested, snow-clad peaks were visible all around and we were fortunate to have fine weather in which to appreciate them. Looking back, a stunning range of mountains could be seen to the north-east beyond Kangding—the Lian Lua Shan (Lotus Flower Mountains)—no doubt one of the views enjoyed by Wilson during his own ascent 103 years before. Ahead the scene was much less promising with dark clouds scudding across the sky alternately revealing and concealing the mountain tops and providing tantalizing glimpses of the pass.

A view to distant Gongga Shan, showing its distinctive peak.

Wilson's miserable end to the day was compounded during the night:

Having at length got rid of our soaked garments—a difficult enough task under the circumstances—we eventually got between the blankets. No sooner had I lay down than a drip came a spot of rain into my eye: I turned over and drip came another into my ear. I twisted this way and that way, but there was no escape. Like evil genii these rain-drops pursued me turn which way I would. I could not move my bed, since this was longer than the tent was broad, and my feet already exposed, and we sorely afraid the whole thing might collapse, it being anything but secure ... About 4 a.m. our firewood gave out and things assumed a very dismal aspect. However, all things have an end; day at length dawned and all were devoutly thankful ... With what fire remained we managed to boil some water and make some tea. We breakfasted on ship's biscuits and cheese and felt none the worse for the night's experience.[8]

Wilson was, above all things, a fatalist.

The rain stopped and Wilson and Edgar prepared for the day's work, during which they hoped to find the lampshade poppy. A farmhouse, one thousand feet below their overnight position, was commandeered and their cook, who was suffering from severe altitude sickness, was taken down to recuperate. The journey to the pass began at 7.a.m. and after some initial rain showers continued on in sunshine. The alpine flowers captivated Wilson; in early summer these Chinese mountains are amongst nature's most exquisite natural gardens. Tony and I arrived at the peak of the display and we left the vehicles three or four hundred meters below the pass and proceeded on foot. By the roadside, a braided mountain stream provided ample moisture and it was in this sodden turf that the greatest diversity could be found. *"I wish I had the ability to describe this floral paradise with all its glories, but this is beyond me,"* wrote Wilson.[9] I certainly won't try where Wilson failed and hope that the images reproduced

The flora of the moist ground below the Ya-jia Pass is replete with a wonderful array of colorful flowers, including *Rheum alexandre* (left) and *Primula secundiflora* (right)

on these pages will give the reader a hint of the individual and collective beauty of these mountain flowers, many of which have become firm garden favorites amongst discerning growers.

We followed Wilson's and Edgar's route to the pass knowing that at any time the lampshade poppy would appear. Our experience was almost exactly as theirs had been:

> *At 11,000 feet I came across the first plant of* Meconopsis integrifolia*! It was growing amongst scrub and was past flowering. I am not going to attempt to record the feelings which possessed me on first beholding the object of my quest to these wild regions ... I had travelled some 13,000 miles in five and a half months and to be successful in attaining this first part of my mission in such a short time was a significant reward for all the difficulties and hardships experienced en route.*[10]

The lampshade poppy is a monocarpic species, dying after flowering, but it produces ample seed and has proved to be relatively amenable in cultivation particularly in the cool summer climate of Scotland.[11] Wilson's plant became an instant success, flowering in its first season in the Veitch nursery and persisting for many years.[12] All the recent trips to this and neighboring parts of China have reinforced its presence in cultivation and it is not unusual to see this plant flowering in northern gardens. In cultivation it has also produced several attractive hybrids with other Asiatic species such as *M.* × *beamishii* (*M. integrifolia* × *M. grandis*) and *M.* × *finlayorum* (*M. integrifolia* × *M. quintuplinervia*). In recent years botanical opinion, particularly that of Dr. Chris Grey-Wilson, has suggested that this variable plant is easily divisible into two distinct entities—*M. integrifolia* and *M. pseudointegrifolia,* the latter a plant with nodding and more open flowers, quite distinct from Wilson's plants that have globular and more upright flowers.[13]

After this first plant the mountainsides began to reveal a veritable cornucopia of poppies. Wilson recorded that *"as we continued the ascent,* Meconopsis integrifolia *became more and more abundant. At 12,000 feet and upwards, miles and miles of the alpine meadows were covered with this plant, but only a few late flowers remained."*[14] Being a month earlier Tony and I caught every plant in full flower, the sun-disk blooms swaying in the mountain breeze, flaunting their wares for any passing bees. Our climb continued in deteriorating conditions until we reached the pass at nearly 4,000 meters. Wilson tells us of the fear that the Ya-jia Pass engendered amongst his Chinese followers who were not, by nature or inclination, mountain people: *"this Ya-kia pass enjoys an unenviable reputation, and is much dreaded on account of its asphyxiating winds. It is said to be the only pass in the neighborhood which 'stops peoples' breath'."*[15] On reaching the pass we were forced to concur, for though it was June 17, the temperature hovered around freezing point and a biting wind blew from the bleak Tibetan Plateau to the west, bringing pulses of sleet in its wake. Despite this we were thrilled to take an image at almost exactly the same location as Wilson had when he re-visited the pass on 19 July 1908.

Wilson stayed a second night on the mountain, this time in the more salubrious surroundings of the farmhouse that had been commandeered for the use of

ARCHIVES OF THE ARNOLD ARBORETUM

The caption for this 1908 Wilson photograph reads: ***Tachien-lu, near, W. Szechu'an. The Ya-chia-k'an snows and alpine regions clothed with dwarf junipers and rhododendrons. 13,000 feet. July 19, 1908.***

his party. This proved to be a clean, dry, cozy dwelling, and to add further to their good fortune his cook was quite recovered and prepared a hot meal for the team.

On the next day of our trip a most intriguing incident occurred, something that caught me quite by surprise. I have already mentioned Gongga Shan, the giant peak that dominates the Da Xue Shan range. It is the highest mountain in Asia outside of the main Himalayan chain and it exerts a baleful influence. Numerous glaciers grind their way down its flanks and such is its size that it generates its own climatic conditions over a sizeable swathe of the surrounding country. This mountain has always fascinated me. Despite dominating the area it is frequently covered in cloud: I have journeyed to five key vantage points—east, northeast, west, and south of the peak—and been disappointed to find a shroud-covered summit every time. In all his writing Wilson never mentions this mountain either as Gongga Shan or Minya Konka, its Tibetan name. How can this be? During his visits to China he spent many months in the Da Xue

A current view of the barren and desolate Ya-jia Pass, unchanged since Wilson and Edgar first came here.

Shan, surely he must have heard some local reference to the peak or glimpsed some distant view? Given his silence on the matter the obvious conclusion was that he was also unlucky and never had a clear view of the summit nor did he hear mention of it amongst the local people.

As Tony and I wandered the lonely slopes around the Ya-jia Pass I pondered this matter, knowing that the giant mountain lay to the southwest of our position. All around us were shattered and snow-clad peaks. It would have taken a strenuous hike into the higher reaches to breast these in order to provide an unencumbered view to the southwest, and time didn't allow this opportunity. In the warmth and comfort of our 4x4 as we took the road back to Kangding, I re-read Wilson's account of his first journey to the Ya-jia Pass, particularly the second day of his visit. One paragraph leapt from the page. Although I had pored over all Wilson's writings for the best part of the previous 18 months, the significance of the words had, until now, escaped me:

The moraine in front of us terminated in tremendous fields of ice, glaciers of a virgin peak, 21,000 feet high. The sun shone brilliantly and we got a magnificent view of the surrounding mountains. South, south-west of us lay a gigantic peak, several thousand feet higher than the one mentioned; its summit crowned with snowfields of enormous size.[16]

Gongga Shan? Surely.

The following day it was time to move on to the next phase of our journey. Wilson's first trip in the employ of the Arnold Arboretum, his third visit to China, took place between 1907 and 1909. Released from the economic shackles imposed by the Veitch Nursery he could take a much more expansive view of his activities. The patrician director of the Arnold Arboretum, Charles Sprague Sargent, encouraged Wilson not only to "science-up" his work—more emphasis on herbarium specimens and greater attention to field notes—he also insisted that a comprehensive photographic record of the journeys be produced. In a letter to Wilson dated 6 November 1906, a copy of which can be found in the Wilson archive at the Arnold Arboretum, Sargent explains:

> *I write to remind you of the very great importance of the photographic business in your new journey. A good set of photographs are really about as important as anything you can bring back with you. I hope therefore you will not fail to provide yourself with the very best possible instrument irrespective of cost.*

The hardy and ubiquitous *Rhododendron prezwalskii* covers huge areas of the high mountains above Kangding.

The local flora is occasionally put to a novel use; this Tibetan girl is using an *Incarvillea* flower as a kazoo.

Sargent's prescience not only provided us with an excellent series of images of plants and landscapes, which were later published by the Arnold Arboretum, but also a snapshot of Imperial China right at the end of its long history; within a year of Wilson's departure China was effectively a republic.

Thus equipped and instructed Wilson arrived at Yichang, his old base on the Yangtze River, in February 1907 for what was to be his most successful trip, a trip that cemented his reputation as the foremost collector of his generation. I have long felt that the second year of this expedition, 1908, was also his most interesting and productive and in following in Wilson's footsteps I was especially keen to emulate some of his travels during that year. From Kangding we had the opportunity to retrace Wilson's journey of June–August 1908 when he travelled between Dujiangyan (Kuan Hsien) and Kangding, though we would travel it in reverse. Interestingly, Wilson himself was following an earlier traveler—Sir Alexander Hosie—as he tells us:

> *During the summer of 1908, when in Chengtu, I determined upon a journey to Tachienlu. Previously, in 1903 and again in 1904, I had visited this town by three different routes. This time I decided upon following the road leading from Kuan Hsien via Monkong Ting and Romi Chango. The only published account of this route that I had knowledge of is a report by Mr. (now Sir) Alexander Hosie, erstwhile HBM's Consul-General at Chengtu, who returned over this road in October 1904.*[17]

The account Wilson refers to, "Journey to the Eastern Frontier of Thibet", was published as a Parliamentary Report and presented to Parliament in 1905. Hosie took the same direction as Tony and I would, east from Kangding, which he left on 10 October 1904. This was by no means a regular or accepted highway and that is what interested Wilson: *"what I saw of the forests and mountain scenery, together with the quantity and variety of the plants discovered and collected, abundantly repaid me for the hardships experienced."*[18]

My hope was that we could also experience some of this scenery and plant diversity. But could we retrace the route and match some of the many images that Wilson had taken on this journey?

Things began disappointingly. Wilson had travelled on foot on the east side of the Da Xue Shan between Kangding and the village of Hsin-tientsze and even

The new temple at Tagong with the massive bulwark of the Da Pao Shan behind.

today there is no suitable road for motorized vehicles. This meant that we would have to drive up the west side of the range before rejoining Wilson's route beyond Hsin-tientsze. Fortunately, apart from stunning views of some of the snow-clad peaks and a range of hot springs at Je-shuit'ang, it seemed we would miss nothing of great import. No images of particular interest record this section of the journey. We left Kangding taking the road up and over the Zheduo Pass. In the sunlight the roadsides were bright with wild flowers, many of a striking nature, including the large flowered but short-statured Tibetan lady's slipper orchid (*Cypripedium tibeticum*) with large maroon pouches. At the pass we had a something of a shock. Having been at this lonely spot in 2001 we were dismayed to find that things were much changed. A wooden belvedere had been built about 150 meters above the pass, reached by a flight of steps, and another building was under construction nearby. No doubt these developments are underpinned by good intentions, this spot is very much on the tourist route, but it somehow seems quite inappropriate to despoil these pristine alpine areas with such frippery. We didn't dwell.

On the other side of the pass we got stuck behind an endless convoy of lumbering army trucks, which slowed the pace considerably. One of the positive results of this inconvenience was that we were able to continue to admire the carpet of flowers in the grassy alpine pastures. Unlike the valleys to the east, the west

side of the Da Xue Shan is quite dry and few trees are to be found. As a result extensive grasslands are a feature and at this time of year they boasted a display worthy of the most colorful flower garden. The turf was studded with gorgeous plants—*Incarvillea delavayi, Meconopsis horridula, Lilium lophophorum*—odd specimens of *Rhododendron capitatum* formed hummocky mounds amongst the grass sward and the horizon was an endless, undulating green line. Eventually we turned north leaving the army to continue their procession into Tibet. The road became more and more potholed and uneven as we proceeded. Along the way the solid architecture of Tibet began to dominate, with farm buildings of substantial size and construction. Many are only seasonally occupied as the inhabitants leave in the spring to spend the summers in the high mountain pastures grazing their herds of yak. We passed through the important religious centre of Tagong, dominated by its richly decorated and ornamented temple. Rising in front of us was another range of impressive peaks, the Da Pao Shan (Big Cannon Mountains). This linked us back with Wilson who enjoyed fine weather during the last leg of his journey, albeit on the other side of the range to our position:

> *The view from the summit of the pass far surpassed my wildest dreams. It greatly exceeded anything of its kind that I have seen and would require a far abler pen than mine to describe it adequately. Straight before us, but a little to the right of our view point was an enormous mass of dazzling eternal snow, supposed to be, and I can well believe it, over 22,000 feet high. Beneath the snow and attendant glaciers was a sinister-looking mass of boulders and screes.*[19]

Unfortunately for us low clouds obscured the actual summit, though Xiao Zhong told us of that on a recent previous visit he had seen nothing of the mountains at all, so perhaps we were not so unlucky.

[. . .]

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Aronia: Native Shrubs With Untapped Potential

Mark Brand

The genus *Aronia* is a group of largely overlooked shrubs native to the eastern United States. *Aronia* species have tremendous potential for use as ornamental landscape plants and as an edible fruit crop. One thing that has held back consumer acceptance of *Aronia* is the unfortunate common name chokeberry—a name unlikely to endear a plant to consumers. The name chokeberry may have been given to *Aronia* because people have observed that the berries are initially overlooked by birds and are only taken later in the winter when they are the last fruits remaining. The strong tannin flavor of chokeberry fruits may seem to be the reason why birds avoid the fruits, but ornithologists point out that it may actually be the relatively low protein content of the fruits compared to other fruits that are more readily taken by birds.

I am always working to enlighten people about *Aronia* and in doing so I have found that confusion abounds when it comes to chokeberry and chokecherry. I regularly have people tell me they are familiar with chokeberry, only to find out that they meant chokecherry (*Prunus virginiana*). *Aronia* is one of the best kept plant secrets around—surprising since this genus is as complex and interesting as it is useful.

Aronia Species and Their Characteristics

Chokeberries are in the Rosaceae and are multistemmed, deciduous shrubs. They readily form rhizomes and can sucker to form small colonies in a non-aggressive manner. Two species

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Red chokeberry's striking fruit display lasts several months.

The leaves of red chokeberry (seen here) are pubescent on the lower surface while black chokeberry leaves lack pubescence.

Red chokeberry has an upright growth habit.

of *Aronia* are generally recognized: *A. arbutifolia* (red chokeberry) and *A. melanocarpa* (black chokeberry). Hardin (1973) suggests that fruit color—red versus black—should be used to differentiate between species. In addition to fruit color, Krussmann (1986) used degree of pubescence on stems, leaves, and inflorescences to distinguish red from black chokeberry. A third species, *A. prunifolia* (purple chokeberry), is generally recognized as having purple-black fruits and amounts of pubescence intermediate between the red and black species. In my observation, the amount of pubescence on plants that could be considered *A. prunifolia* can range from moderate to heavy. Table 1 summarizes some of the characteristics that can be used to try to differentiate red from black chokeberry. Speciation within the *Aronia* genus is far from clear cut and more research needs to be conducted to determine if *A. prunifolia* is a hybrid between *A. arbutifolia* and *A. melanocarpa* or should be considered as part of the *A. melanocarpa* species. (See the taxonomy sidebar for more information on *Aronia* speciation).

The **red chokeberry** grows 6 to 10 feet (1.8 to 3 meters) tall and 3 to 5 feet (.9 to 1.5 meters)

Though not long lasting, red chokeberry's flowers are attractive in the spring.

Red chokeberry has outstanding red fall foliage color.

wide. It is a multi-stemmed shrub with a distinctly upright growth habit. Even though the plant suckers and spreads, it can become somewhat leggy and open at the base. Most of the foliage on a mature red chokeberry will be found in the upper half of the plant. Summer foliage of red chokeberry is shiny or flat green above and grayish tomentose below. New growth on stems is also quite pubescent. Leaves are obovate or elliptical with a short acuminate tip and marginal serrations. Red chokeberry fall foliage turns a vibrant red crimson or purple red and can be spectacular in sunny locations. Even in partly shaded locations the leaves muster a very nice blend of orange and red. In addition to being attractive in the summer and fall, the red chokeberry also flowers in spring, usually in early May in New England. Small white flowers are produced in clusters that are about 1.5 inches (3.8 centimeters) wide and can be so numerous that they cover the canopy surface. The flowers do not last a particularly long time (about the same amount of time as *Amelanchier* flowers), but they do add early season interest to the plant.

Perhaps the best part about the flowers is that they give rise to abundant red fruits in late September and early October. The clusters of small (0.25 inch [.64 centimeter] diameter) fruits are quite showy and typically remain firm, glossy, and attractive through December. As stated before, birds rarely strip the fruits from the plants until after they have lost ornamental appeal.

The **black chokeberry** can generally be distinguished from the red chokeberry (when fruit are absent) by the lack of pubescence on stems and leaf undersides. Black chokeberries are also shorter than their red-fruited counterparts, attaining a mature height of 4 to 8 feet (1.2 to 2.4 meters). Like the red chokeberry, it suckers profusely, but forms dense plants and colonies, rarely appearing very leggy.

Black chokeberry has outstanding, lustrous, dark green summer foliage that turns a pleasing blend of yellow, orange and red in the fall. While

Black chokeberry bears glossy black fruit.

the black chokeberry's autumn foliage display may fall a bit shy of that of its red-fruited relative, it is still superior to many shrubs. Flowers are white, borne in May, and are similar in landscape effectiveness to the red chokeberry. The black fruits, from which *A. melanocarpa* gets its common name, are shiny and larger (0.3 to 0.5 inch [0.8 to 1.3 centimeters] diameter) than the fruits of *A. arbutifolia*. Fruits can ripen as early as mid-July, but they primarily ripen dur-

Table 1: Comparison of red (*Aronia arbutifolia*) and black (*A. melanocarpa*) chokeberry characteristics

RED	BLACK
fruit color cherry red	fruit color black
fruit relatively small (≤ 0.3 inch)	fruit relatively large (≥ 0.3 inch)
fruit ripens Sept.–Oct.	fruit ripens late July–Aug.
fruit persistent into winter	fruit shrivels and drops
leaves, stems, inflorescences pubescent	leaves, stems, inflorescences glabrous
habit upright, leggy at base	habit rounded, full to base
found primarily on damp/wet sites	found on both damp/wet sites and dry sites
inhabits coastal southeastern U.S.	inhabits northeastern and midwestern U.S.

The glabrous foliage of black chokeberry is green in summer and can develop good red to orange and yellow fall color.

A powerline cut with sand overlaying moist seeps is home to red chokeberries in North Carolina.

ing the month of August. Black chokeberries wither soon after ripening and either drop off or persist for a while as "raisins" on the plant. *A. melanocarpa* populations in the upper Midwest typically have more persistent fruit than populations in the Northeast.

Distribution and Habitat

The geographical range for *Aronia arbutifolia* is centered in the southeastern Coastal Plain, but it can be found extending out into suitable habitats westward into the Appalachian Mountains. It ranges from eastern Texas to northern Florida and continues up the eastern seaboard. It is common in much of the Carolinas, Virginia, Maryland, and New Jersey. Although it can be found in New England, red chokeberry occurs much less frequently there and is generally found close to the coast. The center of distribution for *Aronia melanocarpa* is in the northeastern states and the Great Lakes region, with range extension into the higher elevations of the Appalachian Mountains. In the Appalachian Mountains and the Northeast there is considerable overlap of the red and black chokeberry range. Although the information is somewhat incomplete, *A. prunifolia* seems to be found throughout much of the black chokeberry range and extends somewhat into the red chokeberry range.

Aronia arbutifolia occurs in bogs, swamps, savannahs, lowland woods, the edges of water bodies, moist rocky seeps, and moist pine barrens. *A. melanocarpa* occurs in similar wet locations, but can also be found growing on sand dunes, dry rocky slopes, dry bluffs and balds, and grassy areas. You will rarely find *A. arbutifolia* on the same dry rocky bluffs and

One type of black/purple chokeberry environment in Maine.

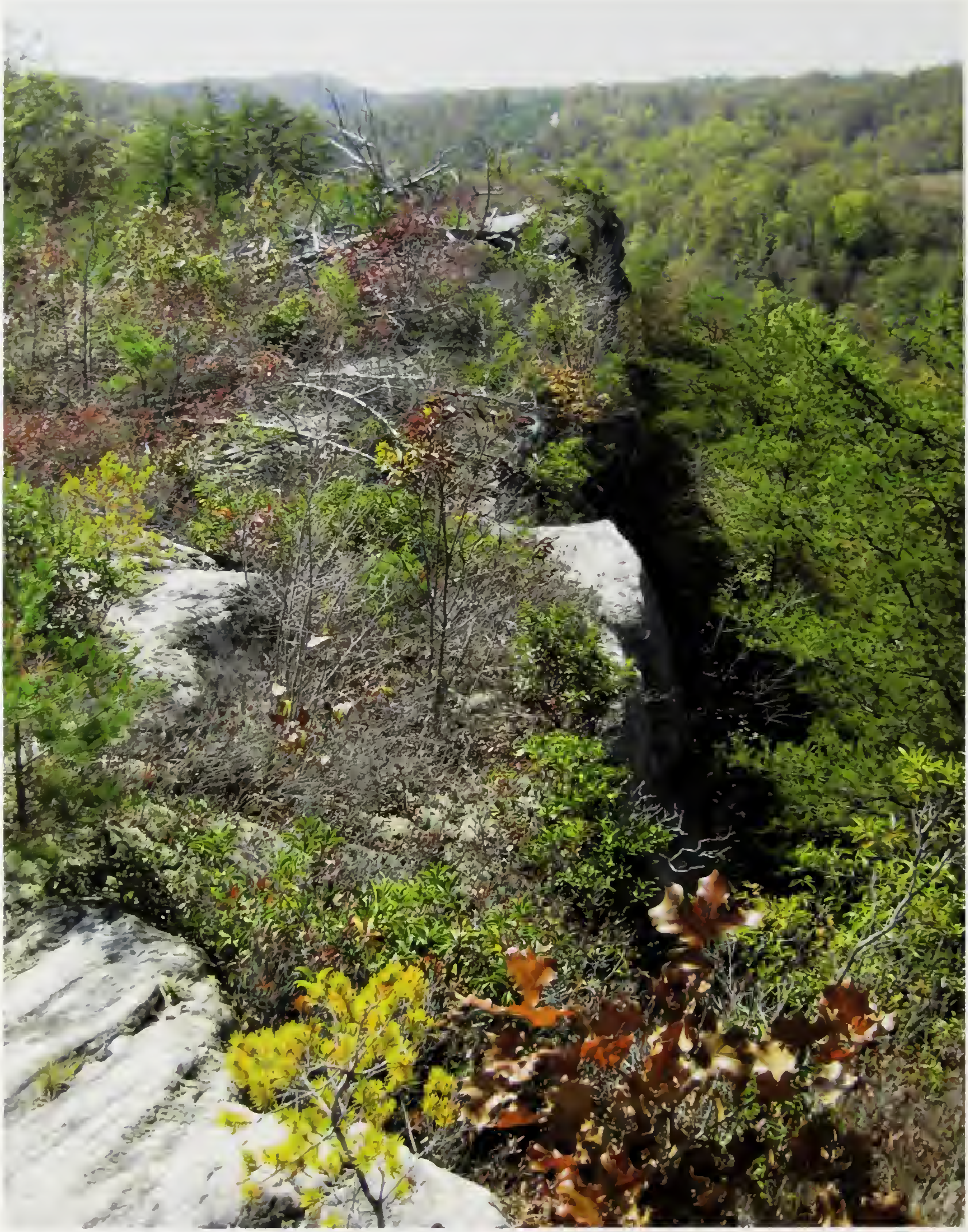
dunes where *A. melanocarpa* occurs, but I have found it growing in thin layers of organic duff on the exposed spines of rock balds. *A. prunifolia* is found in areas similar to *A. arbutifolia*, but also in somewhat drier clearings.

Cultural Conditions

Chokeberries are considered to be hardy to USDA hardiness zone 4 and, with proper genotype selection, the red species can exhibit good heat tolerance as well. Plants can be grown successfully in partial shade or full sun, but better flowering, fruiting, and fall color occur in full sun situations. Both red and black chokeberries seem to tolerate dry or wet soil conditions, even though the red species naturally occurs most often in wet areas. Best growth can be expected in moist soils, but soil type is not critical. Transplanting and establishment are easy with chokeberries even when they are given only modest aftercare. Like most members of the Rosaceae, *Aronia* has a seemingly endless list of insects and diseases that could attack it, but the plants rarely seem to be affected by much and are considered relatively carefree. I have found that powdery mildew can hit *A. melanocarpa*, but it doesn't seem to show up to any degree on *A. arbutifolia*. Lacebug is one insect that I have observed occasionally afflicting black chokeberry growing on hot, dry sites.

Aronia Genetics: Ploidy and Apomixis

Published literature states that *A. arbutifolia* has a 2n number (number of chromosomes in somatic cells) of either 34 or 68 and *A. melanocarpa* has a 2n number of 34 (Darlington and Janaki 1945). At the University of Connecticut I have an *Aronia* germplasm collection of over



This rocky outcropping in the Appalachian Mountains in Tennessee is a typical habitat for *Aronia.*

Taxonomic Teasers in *Aronia*

Over the years, *Aronia* has been placed in numerous genera, including *Mespilus, Pyrus, Adenorachis, Sorbus,* and *Photinia* by different taxonomic authorities (Robertson et al. 1991). Rehder (1949) and Hardin (1973) chose to use the genus *Aronia* for the chokeberries. In 1991, Robertson et al., placed the chokeberries in the genus *Photinia,* citing no differences in floral and fruit morphology between plants formally in the genus *Aronia* and those in *Photinia.* According to Robertson et al., red chokeberry becomes *Photinia pyrifolia,* black chokeberry becomes *Photinia melanocarpa,* and purple chokeberry becomes *Photinia floribunda.* The USDA Plants Database (plants.usda.gov) has adopted *Photinia* as the genus for the chokeberries, but USDA GRIN (www.ars-grin.gov/) is still allowing *Aronia.* Likewise, in the new 6th edition of Michael Dirr's *Manual of Woody Landscape Plants, Aronia* is still being used for the chokeberries. Until more conclusive genetic studies are undertaken, there will likely be continued uncertainty about the correct genus for the chokeberries.

Another point of nomenclatural uncertainty is with *Aronia prunifolia.* Should it be considered a separate species or be folded into *A. melanocarpa* or *A. arbutifolia* as a variety? If it is a separate species, does it have its origins as an interspecific hybrid of *A. arbutifolia* and *A. melanocarpa* and should it be designated as *Aronia* x *prunifolia*? Most of the evidence seems to suggest that the purple chokeberry is the result of interspecific hybridization between red and black chokeberry. We know from our own hybridization work that it is relatively easy to cross red and black chokeberries and get offspring that are not the result of apomixis. We have pollinated diploid black to tetraploid red and have many purple plants which are triploid. Hardin (1973) points out that garden hybrids between red and black have arisen at times and have been referred to as *Aronia floribunda.*

Some have argued that the naturally occurring *A. prunifolia* is something different from *A. floribunda* because it can occur outside areas where the red and black chokeberries are sympatric, but this argument is flawed. It does not take into consideration the likely scenario that interspecific red-black hybrids produce viable seeds apomictically. The purple species could arise at the margins of overlap of the red and black species and then spread by seed to regions far beyond each parent species' range. Purple chokeberry could also spread vegetatively by rhizomes. Furthermore, purple chokeberries seem to occur in the greatest abundance and have the most within-population variability in areas where both the red and black chokeberries overlap. Paper chromatography done in the 1960s on red, black, and purple chokeberry found that purple chokeberry contained the greatest number of unique compounds in comparison to red and black, adding more weight to the theory of hybrid origin (Alston et al. 1965). These arguments, along with the fact that *A. prunifolia* generally has morphological characteristics (degree of leaf/stem pubescence, fruit color, fruit ripening date, plant habit) that are intermediate between *A. arbutifolia* and *A. melanocarpa,* seem to tip the balance in favor of hybrid origin. One bit of work conducted in the 1970s, at the now closed Long Ashton Research Station at the University of Bristol, found that the flavone C-glucoside vitexin is restricted to *arbutifolia* and *prunifolia* x *arbutifolia* material and absent from *melanocarpa* and *prunifolia* x *melanocarpa* material. These findings do not support the involvement of *A. arbutifolia* in the parentage of *A. prunifolia* (Anon. 1974).

100 accessions of black, purple, and red species. So far, based on flow cytometry results, we have not found any diploid (2n=34) red chokeberries. With additional collecting, we hope to find the elusive diploid *A. arbutifolia.* Black chokeberries collected from outside of New England have all been tetraploids (2n=68), while New England black chokeberries have been diploid (2n=34). There are numerous accessions that we believe to be *A. prunifolia* and these plants are either tetraploid or triploid.

There is mounting evidence that suggests that *Aronia* is capable of producing apomictic seeds (Persson Hovmalm et al. 2004). These are seeds that develop without fertilization of the egg and are, therefore, clones of the mother plant. This is particularly true of tetraploid and triploid forms of *Aronia.* Apomictic seed set has been suspected from observations of the homogeneity in cultivated Russian plant material (Poplavskaya 1995). In our own breeding work with *Aronia* at the University of Connecticut, we have found that seedling populations from tetraploid plants are visually identical to the female parent regardless of the ploidy of the pollen used. When we use a diploid female parent, we get segregation within the population. We have also found that triploid *Aronia* produce fertile seed, even though triploidy typically results in sterility. It is likely that polyploid forms of *Aronia* have evolved to produce seed through apomixis as a functional manner in which to reproduce.

Why the Interest in *Aronia*?

The future is particularly bright for *Aronia* and it will undoubtedly emerge from its relative obscurity to serve as both an important ornamental landscape shrub and as a nutraceutical fruit crop. There is growing interest among gardeners, landscapers, landscape architects, and the general public in making better use of our

NANCY ROSE

Chokeberries are versatile ornamental landscape shrubs. A planting of black chokeberry is seen here in fall color.

own native plants, especially when they can serve as alternatives to problematic aggressive and invasive exotic species.

In the Northeast, the popular winged euonymus or burning bush (*Euonymus alatus*) has become invasive and has even been banned in Massachusetts and New Hampshire. Its main landscape attributes are stunning red fall color, dense habit, and easy culture. Since native highbush blueberry (*Vaccinium corymbosum*) also has excellent red fall color it is often recommended as a replacement for burning bush, but it is not adapted to many of the landscape sites where burning bush has typically been employed. *Aronia* can serve as a much better alternative to *E. alatus* because it is site adaptable in addition to having multi-season interest, including red fall color. To become popular ornamental shrubs, chokeberries simply need a little marketing and perhaps a more appealing common name.

In addition to uses as an ornamental, black chokeberry is rapidly gaining momentum as a new small fruit crop for many parts of the United States. The blueberry-sized black fruits produced by *Aronia melanocarpa* have the highest known levels of antioxidants (anthocyanins and flavonoids) of any temperate fruit, five times higher than cranberry and blueberry, and also contain strong anticancer compounds. *Aronia* has been widely grown in Eastern Europe and Russia where the fruits are processed and used in beverages, wine, jelly, and baked goods (Kask 1987). In the United States, *Aronia* is largely unknown as a fruit crop, but there are no obvious limitations to prevent it from becoming popular here as well, especially given the public's growing interest in functional foods. Preliminary work in Iowa, Oregon, Wisconsin, and Nebraska has demonstrated the viability of *Aronia* as a fruit crop in many regions, including New England.

Aronia berries, while edible as a fresh fruit, are much tastier when the fruits have been processed. They are high in sugar (12 to 20% soluble solids), anthocyanins (560 to 1050 mg/100 g fresh weight), have a pH of 3.3 to 3.7, and 0.7 to 1.2% titratable acidity (Jeppsson and Johansson 2000; Oszmianski and Sapis 1988). Chokeberries are very suitable for industrial processing since they are not prone to mechanical damage during transport and have low pectin content (Jeppsson 1999). Moreover, chokeberries can be harvested by machine (Gatke and Wilke 1991) and there is a long harvest window.

Aronia juice products (left to right): aronia blended with acai juice to make a fruit juice drink similar to cranberry cocktail, powdered juice to mix into food or drink as a nutraceutical, and a nutraceutical beverage containing aronia juice.

Since "chokeberry juice" is unlikely to sell, it is usually labeled as "aronia juice." Wine red to dark purple in color, it is often blended with other more flavorful juices such as apple, cranberry, grape, and black currant to make popular beverages. Other common uses include jellies and jams, syrup, soft spreads, teas, wine, and flavorings for ice cream and yogurt. Aronia juice is also an excellent colorant.

The University of Wisconsin-Madison Center for Integrated Systems (Secher 2008) evaluated 13 potential uncommon fruits with sustainability potential. *Aronia* was chosen as the crop with the greatest potential, beating out currants, gooseberries, and elderberries. Low input requirements, high adaptability, high pest resistance, high nutraceutical content, short time to first yield, ease of culture, and high machine harvest potential were given as reasons why *Aronia* is tops for commercial production potential.

The fruit of 'Viking'(left) and typical wild-type *Aronia melanocarpa* (right). 'Viking' and 'Nero' are the primary cultivars available for fruit production in the United States (McKay 2001). Both are tetraploid forms (Brand, unpublished data) with large, relatively sweet berries and are the highest producing cultivars currently available (Strik et al. 2003).

Breeding and Selection

Breeding efforts to improve ornamental chokeberries at the University of Connecticut are focused primarily on red chokeberry. There is a need to reduce the plant's stature by half and eliminate its tendency toward legginess. Another goal would be increased fruit size to provide a more impressive display in the fall and early winter. Fall foliage impact can be enhanced by improving leaf retention as the leaves turn red; currently available forms of red chokeberry tend to drop leaves too quickly after coloring. Selections can also be made for resistance to powdery mildew in black chokeberry. So far, improving red chokeberry has been challenging because all of the accessions we have are tetraploids that probably produce apomictic seed. Finding a wild diploid *A. arbutifolia* could prove to be very useful in breeding this species. Polyploidy can also make it more difficult to use mutation breeding on red chokeberry due to the extra sets of chromosomes that can mask incomplete mutations. Nonetheless, we have made some progress in developing more compact forms of red chokeberry using chemical mutagens and irradiation.

European and Russian breeding efforts to enhance black chokeberry for fruit production have been largely constrained by the highly homogenous gene pool in domesticated Russian plant material. To make progress in this area it is, therefore, necessary to broaden the genetic basis through the introduction of germplasm from native stands (Persson Hovmalm et al. 2004). There is evidence suggesting that flavonoid content of chokeberries can be increased by incorporating native germplasm that contains higher levels of flavonoids into a breeding program (Suciro et al. 2006). Due to apomixis, diploid forms of black chokeberry are at the core of plant improvement efforts at the University of Connecticut. It is unclear whether tetraploid forms are autotetraploids or allotetraploids. It is possible that commercial

Aronia cultivars like 'Viking' could be allotetraploids, since *Aronia* is known to hybridize with plants in the Rosaceae genus *Sorbus*.

Our primary goal at the University of Connecticut is to improve black chokeberry as a fruit crop by increasing levels of antioxidants and anticancer compounds in the fruits while maintaining or increasing fruit size above that found in current commercial cultivars such as 'Viking'. Of course, improving fruit flavor is also important. We are currently trying to unravel the genetics that have given us cultivars like 'Viking' and 'Nero'. Some authorities designate the large fruited black chokeberries as *Aronia mitschurini* (Strik et al. 2003). In the late 1800s and early 1900s, Russian and eastern European breeders had significant *Aronia* breeding programs. Ivan Michurin, a Russian plant breeder, produced a plant called 'Likernaya' that is an intergeneric hybrid between *Sorbus aucuparia* and *Aronia melanocarpa* (Kask 1987). It is possible that this intergeneric hybrid, or others like it, were eventually back crossed to *A. melanocarpa* to give rise to cultivars such as 'Viking'. By understanding how 'Viking' was created, we hope to re-create superior large-fruited forms for the fledgling domestic chokeberry fruit industry.

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Forest Farming

Ken Mudge

Many sections of the Northeast have been reforested over the past century. Extensive forest cover is seen in this view from Wachusett Mountain in central Massachusetts.

Farmers harvest crops from their fields, and loggers harvest trees from their forests, but what do forest farmers harvest? The answer is an eclectic collection of non-timber forest crops like maple syrup, medicinal herbs, fruits, gourmet mushrooms, and nuts.

Forest farming is an approach to forest management that combines some of the management practices of conventional forestry with those of farming or gardening to achieve an environmentally and economically sustainable land-use system. It is one of several related practices that fall under the domain of agroforestry—a multidisciplinary approach to agricultural production that achieves diverse, profitable, sustainable land use by integrating trees with non-timber forest crops.

While some other agroforestry practices begin with planting young trees that take years to mature, forest farming involves planting non-timber forest crops beneath the canopy of an established forest. In other words, other agroforestry practices bring the forest to the crops, whereas forest farming brings the crops to the forest. In this regard it is helpful to consider the role of forest farming in overall forest man-

agement. A forest farm should be designed to emulate as much as possible a natural forest. This includes characteristics of a healthy forest ecosystem such as species diversity, resilience to disturbance, soil health, and a relatively wide tree age distribution.

Forest Farming Through the Ages

Although this article will focus on modern temperate region forest farming, similar practices have been used in tropical regions by indigenous peoples for hundreds of years. In a classic paper from the agroforestry literature, Fernandez et al. (1984) described an agroforestry practice called home gardens, used by the Chagga people who live on the slopes of Mt Kilimanjaro. Home gardens are highly integrated, multistory collections of overstory forest trees valued for timber, an intermediate layer of small trees including coffee and banana, and a diverse array of understory herbs and vines used for food and medicine. In North America, during and prior to the seventeenth century, native peoples are known to have planted and managed various food bearing trees including walnuts and peaches, but there is no evidence of deliberate cultivation of useful crops beneath the canopy of established forest.

Although some types of forest farming and other agroforestry practices have been going on for centuries, the terms "agroforestry" and "forest farming" are of relatively recent origin. Agroforestry—as a concept that recognized the integration of trees, crops, and people—was introduced in 1973 by John Bene, and led to the establishment of the International Council for Research in Agroforestry (ICRAF) in Nairobi, Kenya which is now the World Agroforestry Center . It was not until 2000 that the term forest farming was introduced by Hill and Buck (2000) to describe the cultivation of non-timber forest crops beneath an existing tree canopy.

One factor contributing to the growing popularity of forest farming in northeastern North America is the gradual increase in the extent of privately owned forest. Using the state of New York as an example, forest cover was at a minimum of about 15% in 1880 because of extensive conversion of forest to farmland.

Farming or Wildcrafting?

Although there is no anthropological or archeological evidence that Native Americans practiced forest farming per se, unquestionably they were highly skilled at gathering and utilizing wild forest products, including food, medicines, and ceremonial plants. Prospective forest farmers today frequently ask if the collection of wild forest products like edible mushrooms, wild leeks (ramps), ginseng and other medicinals, and decoratives like pine cones for wreaths and vines for basketry can be considered forest farming. These practices, known collectively as wildcrafting, are certainly compatible with forest farming, particularly when done on a sustainable basis, but don't qualify as forest farming (i.e. cultivation) unless they are practiced in combination with deliberate cultivation of non-timber forest crops.

NANCY ROSE

Wild-collected morel mushrooms.

Reforestation since then has gradually increased forest cover to 65%, and about 60% of that is privately owned. At the same time average parcel size has decreased, making timber extraction a less economically feasible option. This transition from "industrial" forestry to "investment" forestry by owners who consider forestry a part-time activity or even a hobby makes forest farming an attractive management alternative. Those interested in forest farming include conventional farmers, many of whom have woodlots on their farm, but also private forest owners with non-farm day jobs who want to use their forest productively while preserving or restoring the natural ecosystem. In either case, supplemental income associated with sale of non-timber forest crops can be the deciding factor, although many forest owners pursue forest farming as a source of non-timber forest products for the family, or simply as a source of personal satisfaction.

Becoming a Forest Farmer

Before starting, the forest owner should consider site issues beyond just "Can I grow ginseng (and/or any other crop) at this site?" A successful forest farm should be seen as an integrated agro-ecosystem that satisfies the owners goals while sustaining ecosystem components including soil, water, trees, and wildlife.

A forest farm often begins with a more or less natural (unmanaged) stand of trees. To make it suitable for forest farming, some degree of management is necessary, including management of the forest light environment. For the medicinal herb ginseng (*Panax quinquefolius*), up to 70% shade is necessary, and for mushrooms like shiitake (*Lentinula edodes*), the more shade the better. On the other hand, fruit crops like blackberries (*Rubus* spp.) and pawpaw (*Asimina triloba*) perform best under moderate shade. Light management practices include pruning, selective tree removal, utilizing natural gaps in the forest canopy, and planting less shade-tolerant crops along the forest perimeter. Observing the natural distribution of wild relatives can inform decisions about appropriate placement of candidate non-timber forest crops. For example, wild brambles like black raspberry and blackberry typically occur along the ecotone (interface) between field and forest. Attempts to grow cultivated brambles beneath a dense

NANCY ROSE

The banana-custard-flavored fruits of pawpaw (*Asimina triloba*) are a potential forest farming product.

forest canopy rather than along its perimeter generally have not been successful.

While light is an environmental factor that can be managed, others, including soil pH, fertility, slope, and water availability, cannot be modified in forests as easily as in field agriculture. Irrigation, fertilization, and modification of soil pH are not realistic management options in most forest situations. It makes more sense to select crops that are naturally well-suited to the site characteristics.

Types of Non-Timber Forest Crops

There are three major categories of non-timber forest crops used in forest farming: medicinal, food, and ornamental. Ginseng and mushrooms, in the medicinal and food categories respectively, have the greatest proven income potential but there are others in each category well worth considering (see Chamberlin et al. 2009). While cultivation of ornamentals in forest farming systems is less frequently practiced it does have considerable potential.

In traditional farming, crop diversification was considered insurance against the failure of any one crop. Species and temporal diversity are characteristics of a natural forest ecosystem which forest farms ideally should seek to emulate. For example, in a forest farm growing mushrooms, maple products, and ginseng, diversification makes good sense from a production standpoint; maple is tapped yearly, mushrooms yield a harvest for several years, while ginseng will take eight years to mature. In this

case, the maples also provide shade for both other crops and additional calcium (in fallen leaves) needed by the ginseng.

Medicinals

The forests of North America have been repositories for a wide range of herbs and other plants and mushrooms gathered for use in traditional medicine. The pallet of medicinal plants collected and used by Native Americans and others was and is extensive, but only a few of these species are cultivated as non-timber forest crops today. To a very great extent, this is due to economic factors, including lack of markets and concomitantly low potential for income generation. Ginseng and goldenseal (*Hydrastis canadensis*) are the two medicinals most often cultivated by forest farmers.

American ginseng (*Panax quinquefolius*) is a shade-loving perennial herb that produces a valuable below-ground storage root. It occurs in hardwood forests throughout most of eastern North America. Although wild populations have declined somewhat because of harvesting, it is still relatively common. American ginseng has been highly valued in traditional Chinese and Korean medicine since it was first exported from North America in the seventeenth century. Most commercial demand today is from China and Korea. Ginseng is valuable as a forest farming product, but potential growers should use Beyfuss's site assessment techniques (see listing under Additional Reading) before jumping in.

American ginseng is reputed to function in the human body as an "adaptogen," increasing the body's resistance to stress. In traditional Chinese medicine, ginseng is said to promote yin energy and have a calming effect. This and other beneficial effects of ginseng have been claimed for centuries, but there is little modern scientific research to substantiate these claims. Nevertheless, ginseng is the most valuable of North American medicinal herbs.

The ginseng plant has an unusual growth habit and life cycle that contribute to the relative difficulty and long timeframe involved in cultivating it as a crop. A more typical plant has roots, stem(s) and multiple leaves, each associated with a bud that grows into new branches. Not ginseng. The mature plant consists of a single stalk that looks like a stem, but is in fact a sympodium consisting of the fused petioles (leaf stalks) of its 3 or 4 palmately compound leaves. Ginseng develops a narrow underground rhizome—about the thickness of a good sized-earthworm—with a bud at one end and one or more tuberous storage roots at the other end. A single flush of aboveground growth emerges from the rhizome bud in the spring while the storage root grows slowly during the summer. The plant's slow growth rate is an adaption to its low light environment and results in forest-cultivated ginseng taking about eight years to mature.

KEN MUDGE

American ginseng (*Panax quinquefolius*).

KEN MUDGE

Goldenseal (*Hydrastis canadensis*).

The storage root, which looks a little like a branched carrot, is what all the excitement is about. In Chinese the word for ginseng means "man root," and the more it looks like a person (arms and legs) the more valuable it is to traditional Asian buyers. The root is the source of

The branched storage root of ginseng.

the pharmacologically active compounds known as ginsenosides. When it comes time to harvest the crop, it can only be sold to a licensed dealer if it is intended for export, as is the case with most American ginseng.

The price structure for ginseng is a curious inversion of most other crops. The more intensively it is cultivated, the less it is worth. Large scale, high density ginseng grown in Wisconsin, Ontario, and British Colombia requires expensive artificial shade structures and considerable amounts of fertilizers and fungicides. The wholesale value of this ginseng is about $25 per pound dry weight as of 2009.

As a forest farming crop, ginseng is cultivated either by the "woods-cultivated" or the "wild-simulated" method. "Woods-cultivated" ginseng is grown in raised beds, often amended with organic matter. Its price is about $150 per pound dry weight. The less intensive wild-simulated method involves minimal management—little more than roughing up the ground with a rake, scattering the seed, and coming back to harvest eight years later. It wholesales for about $300 per pound dry weight. This inverse relationship between price and intensity of cultivation extends even to wild-collected (zero cultivation) ginseng which wholesales for $400 to $600 or more per pound dry weight.

Food

North American forests abound with edible plants. However, their use in forest farming is limited since few of these forest edibles can be grown in sufficient quantity, in a reasonable period of time, and be sold for a reasonable price. Food crops that are most likely to be found in a forest farm include gourmet mushrooms like shiitakes (*Lentinula edodes*), berries, other fruits such as pawpaw (*Asimina triloba*), ramps (*Allium tricoccum*), and tree nuts such as walnuts (*Juglans* spp.) and hickories (*Carya* spp.).

Forest-cultivated mushrooms deserve serious consideration for those starting a new forest farming venture. Most candidate crops like medicinals, fruits and nuts, or ornamentals require specific site conditions, but since mushrooms are grown on logs they are less dependent on factors like soil moisture, pH, and drainage. Mushrooms are not photosynthetic and therefore can tolerate nearly complete shade, and a shady site is essential to minimize excessive drying of the substrate logs. Aside from socioeconomic factors like access to markets, mushrooms can be cultivated almost anywhere as long as there is sufficient shade and a source of substrate logs.

Mushrooms are less valuable per pound than ginseng, they are more perishable, and their cultivation requires more labor than ginseng. On the other hand, $8 to $16 per pound fresh weight for shiitake mushrooms is not a bad price when you consider that you can start harvesting mushrooms in as little as one year after log inoculation, and continue harvesting from the same log for 3 to 5 years. By contrast, once a ginseng root is harvested, the plant is gone.

Other mushrooms including lion's mane (*Hericium* spp.), oyster (*Pleurotis* spp.), and hen of the woods (or maitake) (*Griffola frondosa*) can be cultivated under forest farming conditions but cultivation strategies are not yet as well worked out as for shiitake. People curious about mushroom cultivation often ask about the ultra-valuable truffles (*Tuber* spp.), which can sell for nearly $1000 per pound, and valuable morels (*Morchella* spp.). It is probably best to discourage all but the bravest and most patient entrepreneurs from investing time or money in cultivating truffles—many have tried to grow them but very few have succeeded. Similarly, there are very few who have successfully grown morels, which are best left to wildcrafting.

By far the most reliable mushroom for forest cultivation, and for which there is the greatest commercial demand, is shiitake. While log-

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Lion's mane (*Hericium* spp.) and oyster mushrooms (*Pleurotis* spp.) can be cultivated in forest farms, though not as reliably as shiitake.

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Forest-farmed shiitake mushrooms ready for harvest.

grown shiitake can be a reliable non-timber forest crop for forest farming, it is worth pointing out that most shiitake mushrooms available to the public are grown indoors on artificial (sawdust) logs, in expensive climate-controlled rooms. The quality of these artificially cultivated shiitake is generally considered inferior to log-grown shiitake mushrooms.

Shiitake is a primary saprophytic fungus that derives its nourishment from dead organic matter; in forest farming, freshly cut logs provide the substrate. The goal of shiitake cultivation is to facilitate the decay of the log through a process by which the fungal mycelium (aggregated fungal strands, or hyphae) enzymatically digests the wood by degrading lignin and cellulose, producing carbon dioxide, water (products of respiration), and the energy necessary for the fungus to assimilate the remaining carbon into new mycelium and reproductive structures, that is, the mushrooms.

Since shiitake competes poorly with other fungi, the substrate logs for production must be freshly cut and lack competing decay organisms. Freshly cut logs also provide the high moisture content necessary for fungal colonization after inoculation. A number of deciduous hardwood tree species make good shiitake substrate. Oaks (*Quercus* spp.) are considered the gold standard in the Northeast but sugar maple (*Acer saccharum*) also rates highly. Tulip poplar (*Liriodendron tulipifera*) is particularly desirable further south. Conventional wisdom says that species with tight bark that helps maintain a high moisture content make the best shiitake bolts, yet our research has shown that aspen, which maintains a higher moisture content than oak, beech, or red maple, is the poorest with respect to shiitake production. Interestingly, in our tests ironwood, or American hornbeam (*Carpinus caroliniana*) outperformed red oak.

Cut logs are then inoculated with spawn, a pure culture of shiitake fungal mycelium (not spores) grown on sawdust or other substrate which is introduced into holes drilled in the logs. Production of uncontaminated spawn must be done under sterile laboratory conditions, so most growers purchase their spawn from commercial producers. An approximately \$20 bag of spawn inoculates about 20–30 logs. Once inoculated, the logs are transferred to the

The MacDaniels Nut Grove: A Unique Educational Site

Practicum in Forest Farming is a multidisciplinary course taught at Cornell University. What makes the course unique is not only the subject matter but also the MacDaniels Nut Grove, the outdoor classroom where the course is taught.

Both are an outgrowth of the rediscovery, in 2000, of a more than 70-year-old temperate nut tree variety trial established in the 1920s by Professor Lawrence MacDaniels. Not long after Dr. Mac (as he was known) retired in 1956, the site was abandoned. Soon, it was all but forgotten as it reverted to secondary forest including oak, hickory, maple, cherry, and invasive honeysuckle. Fifty or more years later, the only obvious sign that the seven acre site was once a repository for hickory and walnut clonal varieties was an abundance of graft unions on over 100 of the older trees. When Dr. Mac was acquiring and grafting scions (upper portion of a grafted plant) onto understocks (lower portion), little was known about the limits of genetic compatibility between different hickory (*Carya*) species. Graft unions between genetically compatible scion/stock combinations like *C.* x *dunbarii* (*C. laciniosa* x *C. ovata*) grafted onto a shagbark hickory (*C. ovata*) understock are barely evident today. Other combinations like shagbark hickory grafted onto red pignut hickory (*C. ovalis*) showed extreme bulging and cracking at the graft union, signs of delayed incompatibility.

When the site was rediscovered it was easy to recognize it as a nut tree variety trial, but it didn't take long to envision it as an outdoor forest farming classroom for Cornell students and members of the community. The course is structured around experiential learning, combining a wide range of outdoor activities with related reading and writing assignments. A field trip to Cornell's Arnot Teaching and Research Forest lets students learn about ongoing mushroom and ginseng research, including hands-on inoculation of freshly cut logs with shiitake mushroom spawn and digging young ginseng seedlings from a wild-simulated (not wild) ginseng patch. Both the logs and the ginseng are brought back to the MacDaniels Nut Grove for further learning activities. Additional activities include soil analysis, vegetation inventory, site indexing to gauge suitability for a given tree species, and forest stand improvement. Data collected in each of these categories contribute to an ongoing GPS database of the MacDaniels Nut Grove. As an integrator of all these hands-on activities, student groups work on a final project involving a systematic permaculture-inspired approach to site assessment and design using an explicit set of "forest owner" goals developed by each group in order to synthesize a final design.

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A view into the MacDaniels Nut Grove, teaching site for Cornell's *Practicum in Forest Farming*.

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(A) shows an incompatible graft union (*Carya ovata* on *C. ovalis*) and (B) shows a compatible graft union (*C.* x *dunbarii* on *C. ovata*).

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A laying yard of logs inoculated with shiitake mushroom spawn.

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These hostas are being forest-farmed in a pot-in-pot nursery production bed. Netting prevents deer browsing.

laying yard where they will incubate while the fungal mycelium colonizes the log. The laying yard must be well shaded (about 80%) year round to minimize moisture loss from the logs. Production of mushrooms for harvest typically occurs about a year after inoculation.

Ornamentals

The North American public spends a considerable amount of money on plants used as ornamentals, either in gardens or for decorative purposes around the home (e.g. cut flowers). Ornamental plants like roses or lilacs that thrive in full sun are not well suited for forest farming, but there is plenty of demand for shade-tolerant garden perennials including hostas, daylilies, ferns, heucheras, trilliums, astilbes, and hellebores. Note that some of these are forest wildflowers, but in forest farming the emphasis is on deliberate cultivation and conservation of wild plants so plants are grown, not wild collected.

Two basic nursery production systems are adaptable to forest farming—field (in the ground) and container. Field production can have lower costs but harvest and sale of plants is seasonally limited. Container production makes it easier to harvest, move, and sell plants, but has drawbacks such as wind throw, low and high temperature stress to root systems, and higher water needs from restricted rooting volume.

A newer method, pot-in-pot production, solves many of these container problems and may be well suited for forest farming. This method uses an empty socket pot buried in the ground so that its rim is about even with the soil surface. A second pot containing the crop plant slides down into the socket pot, so its soil line is at about the natural ground line. This prevents wind throw, allows for easy, multi-season harvest, moderates soil temperature within the crop pot, and reduces water use. The latter is particularly useful in most forest farming systems where irrigation is usually not readily available.

Another category of ornamentals for forest farm production includes cut stems, flowers, cones, and vines that are harvested from intact plants that remain alive, ready to produce subsequent crops. Although collection of cones, boughs, bark, etc., is more closely allied with wildcrafting than forest farming, the distinction becomes blurred if a wild plant is deliberately managed to produce a continuous supply of cut products. Woody florals—ornamental stems of woody shrubs such as red-twig dogwood or


NANCY ROSE

Red-twig (or red osier) dogwood (*Cornus sericea*) can be grown as a woody floral for its colorful winter stems.

corkscrew willow used in floral design—are another potential crop, though most woody species in this category would be best suited for planting along the perimeter of a forest farming site. Woody floral shrubs are generally coppiced (cut back to ground level annually) to generate multiple new shoots for harvest each year.

The Future of Forest Farming

Forest farming is not yet a widespread approach to, or component of, forest management, but it has great potential for wider adoption as forest owners look for alternatives to either management of the forest for timber extraction or no management at all. Development of a successful forest farming design should include an integration of the explicit goals of the forest owner with a systematic assessment of both biophysical and anthropogenic characteristics of the site. Ginseng, maple syrup, and forest-cultivated mushrooms have the most reliable track record, and are potentially more profitable than other non-timber forest crops. Others like minor fruits and ornamentals have considerable potential for exploration and development.

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A Soft Touch: *Pinus wallichiana*

Nancy Rose

If any tree could be described as pettable it would have to be the Himalayan pine (*Pinus wallichiana*). Its drooping clusters of fine-textured, luxuriantly long needles positively invite touching. Think of it as the Afghan hound of the conifer world.

Native to the Himalayan Mountains from Afghanistan to Burma, Himalayan pine is fairly common at mid to upper elevations. It grows in valleys and hillsides either alone or with other conifers and deciduous trees including oak, birch, and maple species.

Himalayan pine is known to reach 50 meters (about 160 feet) or more in height in its native range. It typically has a straight central trunk and horizontal to slightly drooping branches. In open, cultivated settings it tends to be shorter (perhaps 15 to 25 meters [about 50 to 80 feet]) and develops an attractive domed or haystack shape. When grown like this, with plenty of space, the foliage display is most attractive. The thin, 15 to 20 centimeters (about 6 to 8 inches) long needles are bundled in groups of five and cascade elegantly from the branches like bluish green waterfalls. The pendant cones of Himalayan pine look similar to those of Eastern white pine (*Pinus strobus*)—light brown at maturity, with flexible scales, and very resinous.

Cold hardiness for cultivated Himalayan pine is somewhat variable depending on provenance. The species has grown well in locations in the United States at least as cold as USDA hardiness zone 5 (average annual minimum temperature -20 to -10°F [-23 to -29°C]). As with some other thin-needled pines, the foliage may suffer winter desiccation damage in windy, exposed sites.

The Arnold Arboretum's first accession of Himalayan pine arrived in January 1874 from The Royal Botanic Gardens, Kew (the plant was removed from the Arboretum in 1892 for unknown reasons). The Arboretum's curatorial records show that this accession was received under the name *Pinus excelsea*, changed to *P. nepalensis*, back to *P. excelsea*, then to *P. griffithii*. These are all synonyms for the now-accepted name *P. wallichiana*.

The Arboretum holds a number of accessions of Himalayan pine. Currently, the oldest living specimen is a large, handsome 1946 accession (268-46-A) originally received from Karl Sax under the name *P. griffithii*. It stands 18 meters (59 feet) tall, has a crown spread of 16.4 meters (54 feet), and a trunk diameter of 97.8 centimeters (38.5 inches) (measured below the first limb). This plant is of unknown garden origin, but the Arboretum does have several accessions of documented wild origin as well.

The specimen pictured at right (accession 83-94-B) arrived as seed from the Quarryhill Botanic Garden, originally collected in October 1993 during a plant expedition to India. The seeds were collected in the northern Indian state of Himachal Pradesh at an elevation of approximately 2500 meters (8200 feet). Of the four specimens of accession 83-94 planted, this one has performed best, perhaps because of its somewhat protected but adequately sunny location behind the Arboretum's maintenance garage. It currently stands 8.3 meters (27 feet) tall and has a DBH (diameter at breast height) of 17.3 centimeters (6.8 inches). We also have two specimens of another accession, 84-94, which originated from the same 1993 expedition but a different location, this one at an elevation of approximately 2300 meters (7500 feet) in the Great Himalayan National Park. One last wild collected Himalayan pine accession of interest is 1277-61-A, grown from seed collected in November 1961 in the vicinity of Kabul, Afghanistan, at an elevation between 6000 and 7000 feet (about 1800 to 2100 meters). Unfortunately, this specimen is in only fair condition but is a candidate for repropagation because of its unique provenance.

Nancy Rose is editor of *Arnoldia*.

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Front cover: The expanding leaves on this red oak (*Quercus rubra*) seedling exhibited a characteristic red blush on May 4, 2009, a warm, overcast, spring day. Read more about the 2009 weather conditions at the Arboretum starting on page 20. Photo by Nancy Rose.

Inside front and inside back covers: Peter Del Tredici profiles the Arboretum's majestic specimen of sand pear (*Pyrus pyrifolia*, accession 7272-C) on Bussey Hill, notable for its prolific spring bloom. Photos by Peter Del Tredici.

Back cover: Oaks (*Quercus* spp.) are notoriously challenging to taxonomists, thanks to the ready ability of oak species to interbreed. Andrew Hipp details his research distinguishing Hill's oak (*Q. ellipsoidalis*) from scarlet oak (*Q. coccinea*) and black oak (*Q. velutina*, pictured here). Photo by Andrew Hipp.

Hill's Oak: The Taxonomy and Dynamics of a Western Great Lakes Endemic

Andrew L. Hipp

The form and fall color of Hill's oak (also known as northern pin oak).

KRIS BACHTELL

Oaks afford a unique insight into the history of our landscape, flora, and vegetation. Oaks have been among the dominant trees of eastern North American forests and woodlands for approximately 10,000 years (Abrams 1992). Between 8,000 and 3,000 years ago, oaks spread to distributions close to those we observe today (Webb 1981). The landscape between the prairies of the Great Plains and the eastern deciduous forest had by that time settled into a broad transition zone in which prairie, woodland, and savanna shifted with the dynamics of climate and fire (Anderson and Bowles 1999). Some oak species in this region could persist below ground for decades as their shoots were regularly burned to the ground, growing to maturity only when a break in fire frequency allowed their stump sprouts to grow (Kline 1997). The oldest oaks still growing have borne witness to fires, changes in forest structure and composition, and substantial anthropogenic landscape changes. These old oaks sustain large numbers of mammals, birds, and insects. Blue jays, squirrels, and, previously, passenger pigeons have eaten, hoarded, and dispersed acorns in vast quantities (Johnson and Adkisson 1986; Keator and Bazell 1998; Price 1999, ch. 1), and civilization rests in part on the structural and nutritional properties of oaks (Logan 2005). It is hard for a North American naturalist to imagine a landscape without oaks.

At the same time, oaks are remarkable for their ability to stump botanists. Even where there are only a few species to choose from, we often struggle to put a name on oaks in the field, and annotations on many herbarium specimens capture decades of disagreement. Oaks are noto-

riously promiscuous, with closely related species able to exchange genes seemingly at will. Pioneering work by James Hardin in the 1970s demonstrated hybridization among 14 of the 16 white oak group species of eastern North America, with hybridization occurring almost anywhere that different white oak species grow in sympatry (Hardin 1975). In the era of DNA-based taxonomy, hybridization has been demonstrated numerous times, using chloroplast and nuclear data (Whittemore and Schaal 1991, Dumolin-Lapegue et al. 1997, Curtu et al. 2007, Cavender-Bares and Pahlich 2009). For this reason, oaks have been described by two leaders in the field of speciation as a "worst case scenario for the biological species concept" (Coyne and Orr 2004, p. 43). Our understanding of the depth and orientation of genetic boundaries, our concepts of what constitutes a plant species, and our ability to differentiate morphologically similar species are tangled up in the oaks.

A worst case in a genus of worst cases

The Western Great Lakes endemic Hill's oak (also known as northern pin oak) (*Quercus ellipsoidalis;* Plate 1) is distinguished by the number of workers who have puzzled over its taxonomic status and proper identification (Trelease 1919; Jensen 1977, 1984; Overlease 1977, 1991; Maycock et al. 1980; Shepard 2009). Hill's oak is a member of the black oak group, *Quercus* section *Lobatae,* a New World lineage of more than 100 species, of which approximately 75 are found in Mexico and 35 in North America north of Mexico. The section is easily recognized in the field by the presence of bristles or awns on the tips of the lobes (in, for example, *Q. velutina, Q. rubra, Q. shumardii, Q. palustris*) or leaf apex if the leaf is unlobed (for example, *Q. imbricaria, Q. phellos, Q. pumila*). Most species in the group also mature acorns over two seasons.

In habitat, Hill's oak ranges from dry sandstone bluffs, oak barrens, and sand savannas to seasonally wet sandy soils and dry-mesic forests in clayey soils. The tree is particularly common in woodlands of northeastern Illinois. Typical Hill's oaks have deeply lobed leaves with more-or-less C-shaped sinuses; leaf undersides that

Plate 1. Hill's oak (*Quercus ellipsoidalis*), showing leaf and acorns. While the smaller leaf size and more ellipsoid acorn are typical of Hill's oak relative to scarlet oak (see Plate 2), leaf and acorn morphology are profoundly variable in Hill's oak. William Trelease (1919) wrote that the "extremes" of morphological variation in Hill's oak acorns range continuously from one to the other and have no obvious segregation on the landscape. This is a remarkable statement in light of the fact that the epithet *"ellipsoidalis"* references the acorn shape, which was instrumental in tipping Rev. Hill off to the species' distinctness. Vouchers of the illustrated specimens are deposited at the herbarium of The Morton Arboretum: A.Hipp #3096 (Hoosier Prairie, Lake Co., IN; leaf), A.Hipp & J.Schlismann #2489 (Middlefork Savanna Forest Preserve, Lake Co., IL; acorn). Illustration by Rachel Davis.

are smooth or at most sparsely pubescent; terminal buds that are silky-pubescent on the distal (upper) third to two-thirds; and acorn caps that are smooth to sparsely pubescent on the inner surface, with scales on the upper surface that have tightly appressed tips. In these characters, Hill's oak is similar to the more widespread eastern North American scarlet oak (*Q. coccinea;* Plate 2), and in fact it was commonly

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Terminal buds of Hill's oak, showing the silky pubescence on the distal (upper) half of the bud that is typical in this species. Hoosier Prairie, Lake County, Indiana.

identified as scarlet oak when first viewed by botanists in the late nineteenth century.

In 1891, Reverend Ernest J. Hill encountered a few populations in the area around Glenwood and Calumet Park, Cook County, Illinois that he identified as scarlet oak "with some misgivings." With further study, Hill judged that the leaf coloration in fall, bark texture, and acorn shape sufficiently distinguished the tree from scarlet oak to warrant its recognition as a separate species, and he published his description of the species in the *Botanical Gazette* in 1899. Subsequent to this work, many botanists accepted that Hill's oak was found throughout the upper Midwest to the exclusion of scarlet oak. However, the distinction between Hill's oak and scarlet oak is not always clear. At their morphological extremes, scarlet oak and Hill's oak are readily distinguishable. Typical scarlet oak has larger leaves and terminal buds; acorn cap scales with broad, glossy bodies and tips tending to be narrow and somewhat elongate/acuminate; and concentric rings of pits around the exposed (stylar) end of the acorn nut that appear as though they were scratched with an etching needle or burned into the acorn. Hill's oak has smaller leaves and terminal buds; acorn cap scales with dull or pubescent bodies and relatively short apices; and usually no rings around the tip of the acorn cap, occasionally one or two small rings. But these characters overlap in the greater Chicago region, especially northwestern Indiana, and as a consequence the taxonomy of these two species has remained in flux.

We began a study at The Morton Arboretum in 2005 to investigate whether Hill's oak, scarlet oak, and the widespread black oak (*Quercus velutina*; Plate 3) are genetically distinct from

Plate 2. Scarlet oak (*Quercus coccinea*), showing leaf and acorns; detail of the stylar end of the acorn illustrates the concentric rings typical of this species. While typical scarlet oak does possess these rings, and typical Hill's oak does not, we have found several specimens of Hill's oak that have one ring or, less commonly, two concentric rings of pits at the stylar end of the acorn. In Hill's oak, these rings are mostly solitary when present, 2.75–3.5 (–5) mm in diameter, but in scarlet oak, they are commonly 2 or more and greater than 3.5 mm in diameter. Vouchers of the illustrated specimens are deposited at the herbarium of The Morton Arboretum: A.Hipp & C.Kirschbaum #2627 (Wayne National Forest, Lawrence Co., OH; acorn largely enclosed in cupule, leaf and branch with immature acorns), A.Hipp #3107 (Tinley Creek Forest Preserve, Cook Co. IL; mature acorn, side view and stylar end detail). Illustration by Rachel Davis.


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Acorns of Hill's oak, illustrating the tightly appressed acorn cap scales that distinguish the species from black oak. Striations on the acorn body are not uncommon in Hill's oak, but also not the rule. Acorn shape in Hill's oak is highly variable. Talltree Arboretum, Porter County, Indiana.

one another. My primary collaborator in this project, Jaime Weber, and I have sampled oaks from 58 sites (Figure 1) and genotyped nearly 700 Hill's and black oaks as well as populations of scarlet oak from Missouri, southern Illinois, southern Ohio, and upstate New York, and of the related species red oak (*Q. rubra*), Shumard's oak (*Q. shumardii*), and pin oak (*Q. palustris*).

We are currently investigating three basic questions. First, are Hill's oak and scarlet oak genetically distinct from one another? Do they show the genetic separation we expect of distinct species? Can we use genetic data to identify morphologically problematic populations in northwestern Indiana and southern Michigan that confound our efforts to understand the natural distribution of Hill's oak and scarlet oak? Second, do local populations of Hill's oak and black oak exhibit gene flow, and does genetic intermediacy between these species correlate with morphological intermediacy? Finally, what is the evolutionary history of black oak section members, and what can this history tell us about the process of oak diversification?

Plate 3. Black oak (*Quercus velutina*), showing leaf and acorns. The loose apices of the acorn cap scales in typical black oak give the cap a fringed appearance clearly visible in the field. In both Hill's oak and scarlet oak, the acorn cap scale apices are more nearly appressed to the underlying scales, giving the cap a smooth appearance. An important but less recognized character for distinguishing black oak is the pubescence on the inner surface of the acorn cap, which is dense and matted in black oak only (illustrated in Hipp et al. in press). Vouchers of the illustrated specimens are deposited at the herbarium of The Morton Arboretum: A.Hipp #3087 (Hoosier Prairie, Lake Co., IN; leaf), J.Hitz & A.Hipp 100505-13 [TAL-013] (Taltree Arboretum, Porter Co., IN; acorns). Illustration by Rachel Davis.

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Growing in a forest understory, this seedling of scarlet oak (left) shows relatively deep lobing of the leaves compared to those of a black oak seedling (right). Chemung County, New York.

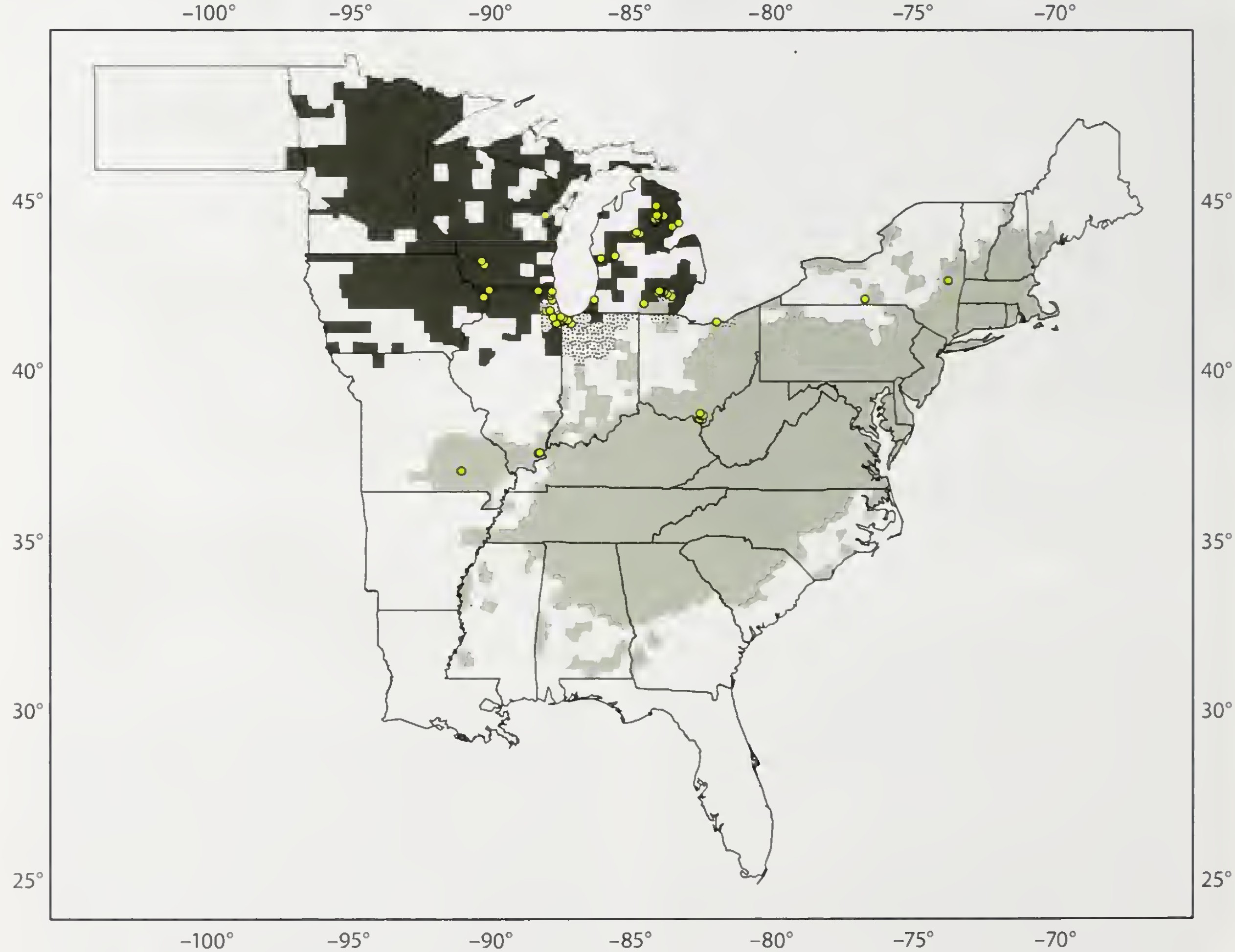

Figure 1. Map of species distributions, with sampling localities. The distribution of Hill's oak (*Quercus ellipsoidalis*) is mapped in dark grey, the distribution of scarlet oak (*Q. coccinea*) in light grey. Speckling indicates counties in which both species have been reported. Dots indicate sites where species were sampled for the current study. Note that only pin oak (*Q. palustris*) was sampled from the northern Ohio locality. Base map adapted from Hipp and Weber 2008, with Indiana distribution according to Biagi and Jensen 1995.

Hill's oak and scarlet oak: two different gene pools

We began our work uncertain as to whether Hill's oak and a genetically distinct scarlet oak were both present in the Chicago region. We also did not know whether we would be able to distinguish closely related species at all using genetic data. Previous workers in the region had found that microsatellite data, which is generated by surveying the genome for rapidly evolving repetitive DNA regions, is not consistently able to distinguish such species as white oak and its relatives (Craft and Ashley 2006) or members of the black oak group (Aldrich et al. 2003). We decided to utilize the amplified fragment length polymorphism (AFLP) technique to genotype trees in this study. The AFLP approach is a shotgun-type approach used for DNA fingerprinting and genome scanning. The method entails cutting the genome of an organism into a large number of pieces at arbitrary points in the genome, then using the size dis-

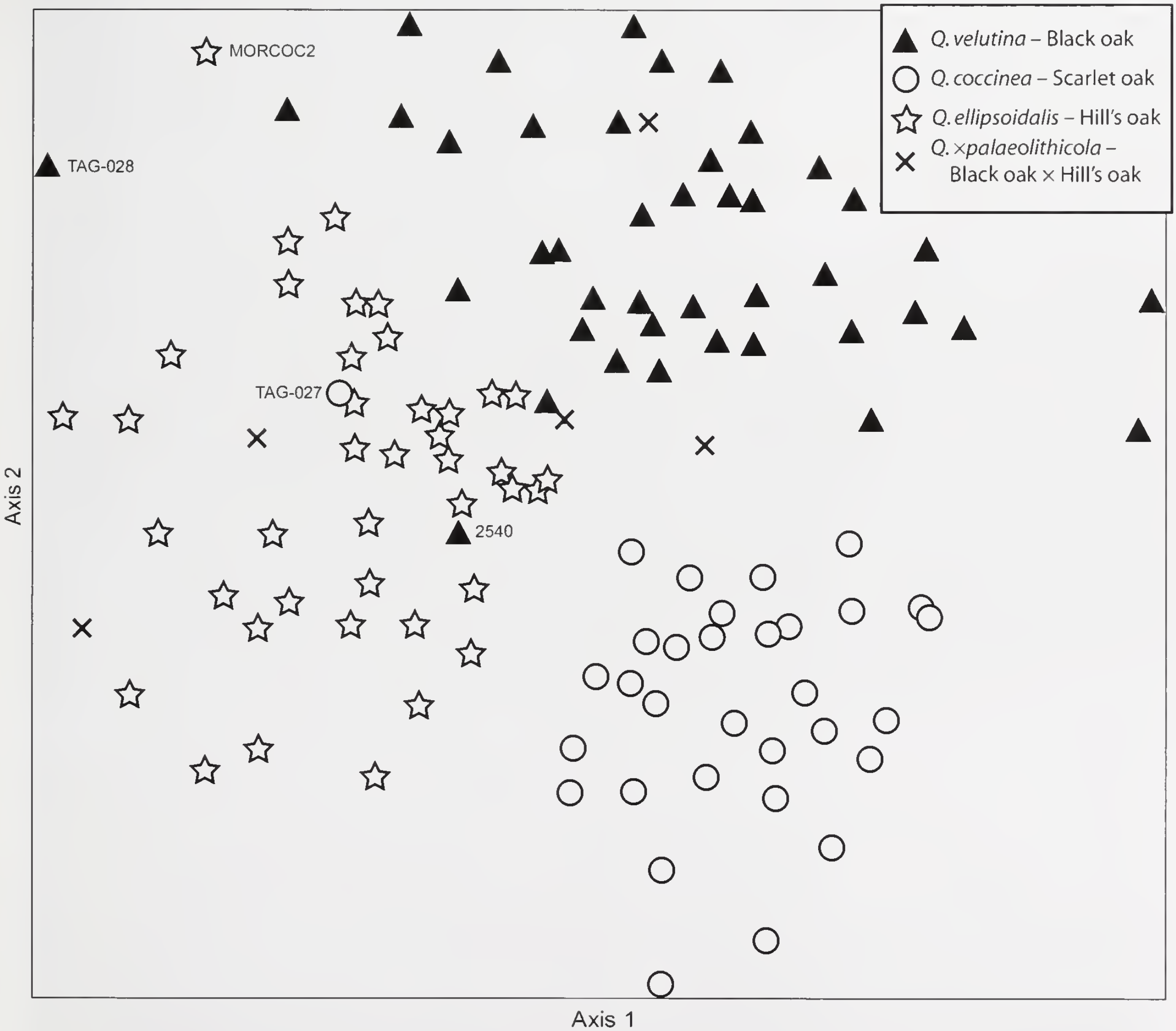

Figure 2. Two-dimensional ordination of 120 individuals representing *Quercus coccinea, Q. ellipsoidalis, Q. velutina,* and *Q. ellipsoidalis* x *Q. velutina* [*Q.* x *palaeolithicola*]. The ordination represents the best two-dimensional spatial representation of the genetic distances among individuals. Stated another way, each point on the figure represents a single genotyped oak tree, and the relative proximity between points represents the relative genetic similarity between trees. Ordination methods and voucher numbers are reported in Hipp and Weber 2008.

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Scarlet oak trunk, illustrating the planed-off appearance of the bark ridges, reminiscent of (though less pronounced than) red oak. Shawnee National Forest, Gallatin County, Illinois.

Leaf of Hill's oak, illustrating the deep lobing typical of this species and scarlet oak. This specimen (TAG-027, housed at the Herbarium of The Morton Arboretum) genotypes decisively as Hill's oak, but morphologically it appears closer to scarlet oak (see discussion in text of article). Talltree Arboretum, Porter County, Indiana.

Foliage of a putative hybrid between Hill's oak and scarlet oak. This specimen (TAG-030, housed at the Herbarium of The Morton Arboretum) is one of the very rare specimens in our study that genotypes as a hybrid between Hill's oak and scarlet oak. These specimens bear further study. Talltree Arboretum, Porter County, Indiana.

tribution of the DNA fragments to estimate genetic similarity between organisms. The disadvantages of AFLP data relative to microsatellite and DNA sequence data is that without directly sequencing AFLP markers, one generally has to assume that markers of a given length are identical by descent and that each marker represents a gene region independent of all others sampled, in which we can identify alleles that are present but not alleles that are absent. These facts render the data less useful for population genetic studies than microsatellite data, but the ability to sample large numbers of genes across the entire oak genome is desirable if we are to detect genetic differentiation even in the presence of interspecific gene flow.

All analyses we have conducted demonstrate a strong separation of scarlet oak from the other species investigated, stronger than the separation between Hill's oak and black oak (Figure 2). It is important to note that genetic divergence alone does not make a species. It has long been recognized that there can be strong genetic differentiation among populations within species (Ehrlich and Raven 1969). However, when genetic divergence between two putative species exceeds genetic differentiation between other closely related taxa recognized as being distinct at the species level, and when this differentiation is associated with geographic distance (allopatry; Figure 1), most biologists are inclined to recognize the taxa as distinct species. The divergence between scarlet oak and Hill's oak must be explained either as divergence between two species or as genetic divergence within a single, wide-ranging species. Although geographic distance may play a role in the strong separation between these two species, we have found in follow-up analyses (Hipp and Weber 2008; Hipp et al. unpubl.) that there is little association between genetic differentiation and geographic distance in black oak across a similar geographic range. When we sample Hill's oaks of northwestern Indiana and southern Michigan that are morphogically similar to scarlet oak (e.g. Figure 2, individual TAG-027), for the most part they do not appear

to be genetically similar to scarlet oak, though the genotypes of a small number of samples we have collected in northwest Indiana suggest that scarlet oak may be present in that area. It is significant that we find very few individuals with genotypes intermediate between Hill's oak and scarlet oak. Naturally-occurring scarlet oak also appears to be rare in the range of Hill's oak, with a few exceptions. First, as indicated above, our data suggest that scarlet oak may be present in northwest Indiana, based on a few specimens that are genetically intermediate between Hill's oak and scarlet oak. However, the one specimen we sampled from northwest Indiana that appears morphologically to be unambiguous scarlet oak (TAG-027) genotypes as pure Hill's oak, and results at other sites where scarlet oak is not present (e.g., central Wisconsin) suggest that occasional genetic assignment discrepancies between Hill's oak and scarlet oak may be a consequence of genetic similarity between the two species. Our findings on this bear more detailed follow-up work. Second, we have genotyped a few trees from a stand of scarlet oaks and other southern Illinois trees previously reported from Tinley Creek Forest Preserve, Cook Co., IL (Shepard 2005). Scarlet oaks from this site are the only trees in our study to genotype as pure scarlet oak in the Great Lakes region, with no evidence of introgression from Hill's oak or black oak. However, they appear to have been planted in the twentieth century, as they occur on former oldfield habitat (pers. obs.). Moreover, smaller trees from an adjacent forest margin genotype as scarlet oak as well, though with minimal evidence of introgression from Hill's oak, and may be natural offspring of these introduced trees. These facts notwithstanding, the strong genetic disjuncture we see between Hill's oak and scarlet oak gives us a great deal of confidence that the morphological intermediacy between them (Shepard 2009) has more to do with intraspecific morphological variation than with gene flow between them. Hill's oak and scarlet oak are distinct species.

Black oak and Hill's oak: gene flow, but not as much as you might think

Having determined that Hill's oak and scarlet oak are genetically distinct from one another, we were interested in understanding the source of genetic similarity between black oak and Hill's oak. In northern Illinois, Wisconsin, and Michigan, distinguishing these two species from each other is not always straightforward. As is the case with Hill's oak and scarlet oak, specimens that lie at morphological extremes are easy to identify: typical black oak has large, densely pubescent terminal buds; acorn caps with loose scales and dense, matted pubescence on the inner surface; and leaves that are often pubescent, even roughly so, tending to be less deeply lobed than those of Hill's oak. However, morphological intermediates are not uncommon (though with good material they are less common than people may suspect), and our first thought was that morphological intermediacy might be predicted well by genetic interme-

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Inner surface of a black oak acorn cap (left) shows the matted pubescence typical of the species while the inner surface of a Hill's oak acorn cap (right) is typically hairless.

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Acorn of black oak, illustrating the loose acorn cap scale tips typical of this species. Talltree Arboretum, Porter County, Indiana.

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Branch of black oak, illustrating the densely pubescent buds typical of the species. Black oak has distinctive yellow petioles at some sites, as illustrated here, but that character is not reliable in much of the range of the species (though in *The Trees of Vermont* by Burns and Otis (1916), petioles of black oak are described as "stout, yellow, 3 to 6 inches long"). Talltree Arboretum, Porter County, Indiana.

diacy. Our attempt to place morphologically intermediate individuals on our ordinations suggests something different: specimens with mature winter buds and/or acorns as well as reasonably intact leaves and that nonetheless have characteristics of both Hill's oak and black oak genotype across a wide range of the two species rather than in a position intermediate between them (Figure 2). Other researchers have found similar discrepancy between morphological and molecular estimates of admixture (e.g., Craft et al. 2002, González-Rodríguez et al. 2004), which may be a product of the complex history of crosses and back-crosses expected in a group of outcrossing, readily hybridizing species like the oaks.

Subsequent analysis of our full set of sampled individuals demonstrates a few misclassifications between black oak and Hill's oak, i.e., incongruence between our identifications based on morphology and the population assignments based on genetic data: 14 black oak out of 286 sampled have > 0.20 assignment to Hill's oak in a commonly used Bayesian population genetic analysis approach. This mismatch between genetic and morphological species assignments is a hallmark of introgressive hybridization and has been reported previously in oaks (Cavender-Bares and Pahlich 2009), and the presence of such individuals supports the hypothesis of gene flow between the two species. It is remarkable, however, that we find so little genuine misclassification or evidence of genetic admixture between black oak and Hill's oak. Our findings build on those of a now-classic study of European oaks (Muir et al. 2000) in demonstrating that while oaks do hybridize, there are enough barriers to interspecific gene flow to make oak taxonomy a meaningful enterprise.

Phylogeny of the black oaks: a little information, a lot to learn

Our work going forward is aimed at understanding how these species and their relatives are related, and how contemporary gene flow and evolutionary history interact to define the limits of today's oak species. Utilizing a larger AFLP dataset and species sampling, we have found that Hill's oak and scarlet oak are sister

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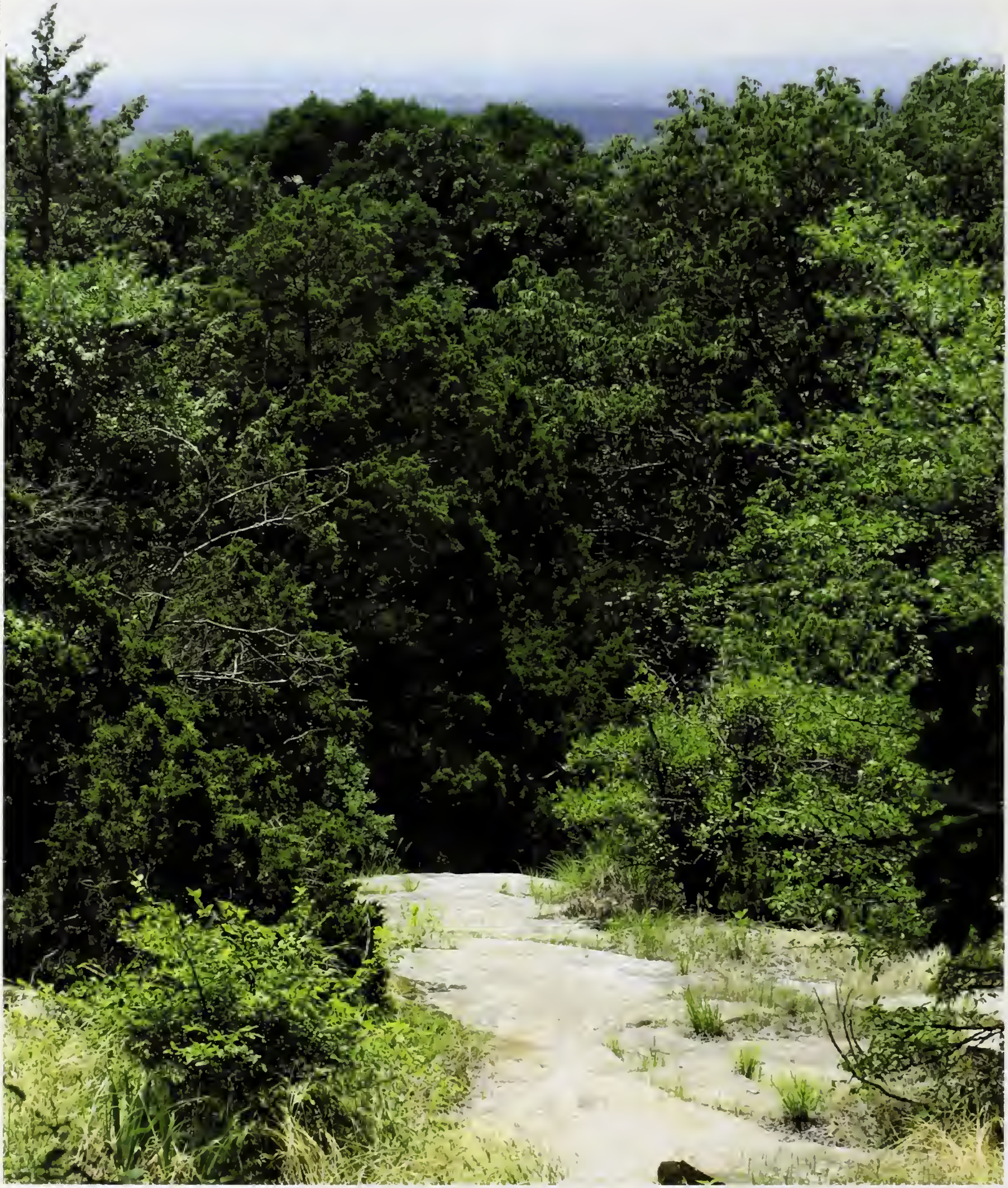

View from High Knob, overlooking a forest of white and scarlet oak. Shawnee National Forest, Gallatin County, Illinois.

species, meaning that they share a more recent common ancestor than either shares with black oak, red oak, pin oak, or any other species. The morphological overlap we see between Hill's oak and scarlet oak suggests that the two species may have inherited a similar pool of characteristics from a recent common ancestor, though these characteristics were inherited in differing proportions.

This finding is particularly interesting in light of the distribution of Hill's oak and scarlet oak. Hill's oak is the only oak species endemic to the Great Lakes region (Abrams 1992) and is distributed almost exclusively in glaciated terrain. It is tolerant of disturbance and has been characterized as the most drought-tolerant of the black oak species (Colodonato 1993), though it appears to be less common than black oak in the driest sand soils of northern Illinois. Its geographic range also overlaps closely with the distribution of dry soil oak savannas in the Great Lakes region (Will-Wolf and Stearns 1999). Scarlet oak, on the other hand, is distributed predominantly south of the edge of the ice sheet at the last glacial maximum. While also tolerant of disturbance and favoring dry sandy or gravelly soils, scarlet oak is not uncommon in mature forests in more mesic soils (Carey 1992). Given the broad geographic extent of scarlet oak and the compressed distribution of hardwood forests during the glacial maximum (Delcourt and Delcourt 1984), these two species likely co-occurred for at least a portion of the Pleistocene. Why, then, has Hill's oak migrated into postglacial environments while scarlet oak is largely confined to unglaciated terrain? It may be that differences in cold tolerance between the two species govern their relative distributions. Hill's oak may also be more tolerant of disturbance or of higher pH or finer soil texture. If so, it may have been more able to take advantage of newly opened territory as the vegetation of the savanna regions around the Great Lakes shuffled around rapidly following glacial retreat. This capacity to respond to relatively rapid environmental change may bode well for Hill's oak in the future. In the shorter term, our growing understanding of oak evolutionary relationships and ecology should allow us to address basic questions about oak distribution and speciation, and guide predictions about how tree species will respond to future climatic and environmental changes.

Acknowledgements

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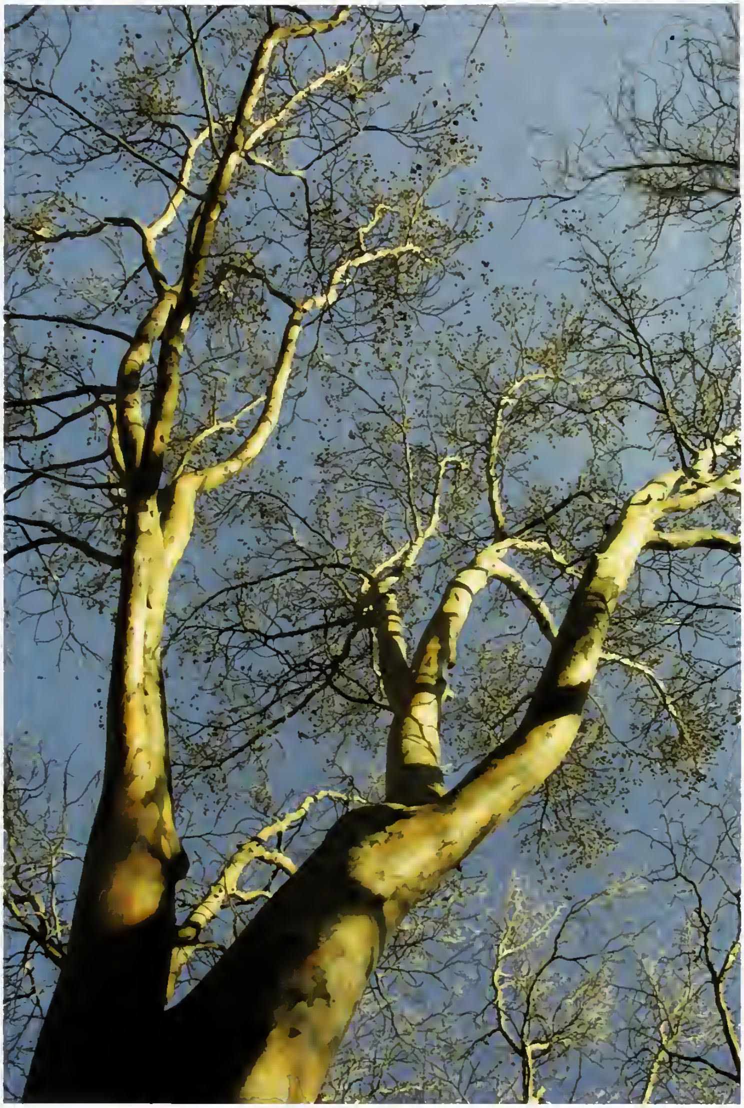
Tree Hormones and Why They Matter

Joseph Murray



The hormone pathway runs from roots to branch tips in trees such as this *Stewartia pseudocamellia.*

Trees are the oldest, largest, and perhaps the most complex organisms on earth. Increasingly, society has moved beyond simply appreciating trees for the beauty and shade they offer, and now recognizes the significant societal, environmental, and economic benefits trees provide. These benefits can be especially important in urban areas, yet many urban sites present very difficult situations for growing trees. Most tree species should be able to live and provide benefits for several hundred years, but urban trees—often plagued by poor soil, restricted root zones, and limited care—rarely achieve even a fraction of their potential life spans. The more we (arborists, city foresters, growers, etc.) know about the biology of trees, the better we will be able to apply proper arboricultural practices to help trees help themselves.

Plant hormones and their effect on tree behavior is an often overlooked aspect of arboriculture. Plant hormones—generally defined as substances produced in very small amounts in the plant that influence the plant's physiological processes—play a crucial role in helping the plant to make adjustments in a changing environment. Knowing more about how plant hormones work in trees helps in understanding the implications of such common arboricultural practices as pruning, planting, fertilization, and irrigation.

What Do We Know About Plant Hormones?

Prior to 1950 in the United States, this article would only have addressed two hormones, auxin and ethylene, which were then considered responsible—by their presence, absence, concentration, or interaction—for everything happening in trees. Today, most plant science textbooks describe five major plant hormones: auxin, cytokinin, gibberellins, abscisic acid, and ethylene. However, there are more than five hormones in plants and research is ongoing.

Plant hormones present a number of challenges to the physiologists attempting to understand how they operate. Plant hormones are produced, and are active, in very small concentrations. At different times during the growing season, different parts of the plant produce specific hormones that influence dis-

NANCY ROSE

Hormones and Tropisms

An interesting example of a hormone causing a plant response is auxin's role in phototropism. A tropism in plants is any growth response resulting in the curvature of a plant organ toward or away from stimuli. Phototropism in plants typically consists of new growth in the shoot system growing toward light. Light striking the side of new growth at the end of branches stimulates the tissues to produce auxin, which then migrates to the opposite (dark) side of the stem where it triggers a physiological response loosening longitudinal cell walls, allowing those cells to expand in length, thus resulting in the curvature of the stem toward the light. Similarly, gravitropism also results in the curvature of the new growth in the root system downward to gravity in response to the unequal cell expansion in the tissue just behind the root tip. In addition to light and gravity, there are many other forms of stimuli that elicit a growth response.

This *Hippeastrum* exhibits phototropism—plant growth bending toward light. Charles Darwin was one of the first to research the mechanics of phototropism and, with his son Francis, published a summary of their observations in the book *The Power of Movement in Plants* in 1880. Later researchers identified auxin as the plant hormone involved in phototropism.

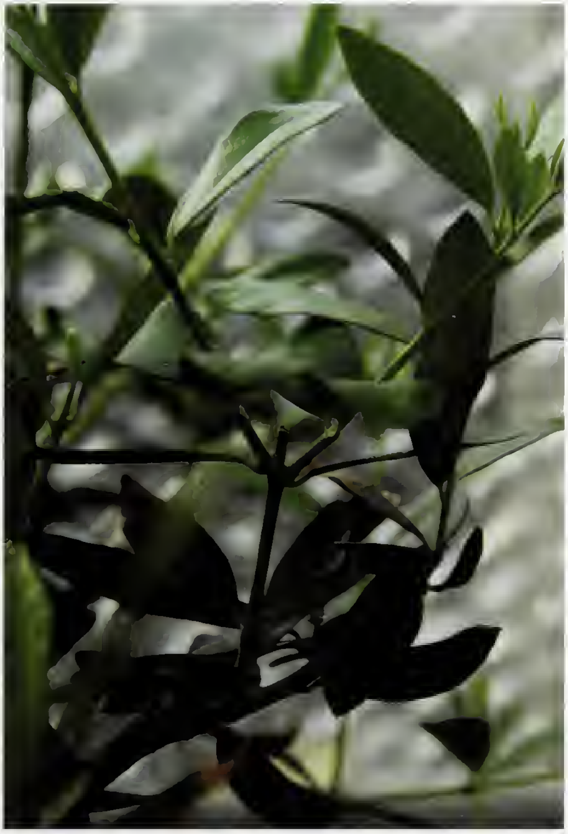
tant tissues that are receptive for brief periods of time. Furthermore, the same hormone may cause two different responses in the same receptive tissues, depending upon the concentration of the hormone.

Hormones are signal transducers, converting an environmental stimulus into a physiological or anatomical response. As an example, let's look at how sunlight makes roots grow in the spring, via a simple pathway using the plant hormone auxin. It makes sense for a tree to invest resources into the root system before the shoot system, so early in the spring sunlight on the shoot apical meristem (bud) and young leaves results in these tissues producing auxin, which travels down to the roots. Hormones in plants may travel throughout the plant but will only affect tissues composed of cells that have special receptors to receive that particular hormone. These target cells may perform a number of functions in response to the arrival of the plant hormone. In a physiological response similar to that described for phototropism (see textbox), auxin stimulates cells at the root tips to release hydrogen ions into the surrounding cell walls. In response to the decreasing pH, enzymes become activated and begin loosening bonds between cellulose microfibrils, thus softening the cell walls. Inside the plant cell is an organelle, the central vacuole, full of water that is continually pressing against the cell wall resulting in turgor pressure. The collective action of softened cell walls expanding in response to the central vacuoles results in the elongation of the root tips. The signal transduction is complete. The hormone auxin allowed the tree to translate an environmental stimulus into a physiological and anatomical response. Simply put, sunlight made roots grow.

The Auxin-Cytokinin Pathway

Many gardeners are familiar with a common technique to produce bushier plants; by simply pinching off the end of a growing stem,

NANCY ROSE



Removal of the branch tip (center of photo) disrupted the auxin-cytokinin pathway, allowing lateral shoots to develop just below the removal point.

there is a proliferation of branch development below the area that was removed. This growth response demonstrates what happens when the auxin-cytokinin pathway is disrupted.

The downward flow of auxin creates a pathway from the terminal buds to the root tips. As mentioned, the auxin acts as a signal transducer, notifying the roots that it's spring and it would be in the best interest of the tree to begin growing roots for the season. In addition to growth, the tissues in the root tips produce the hormone cytokinin. Cytokinin, like auxin, is going to stimulate growth as well, but in a different location—at the ends of the very branches that originally established the auxin pathway. Each spring, the auxin-cytokinin pathway promotes the timely growth of the root and shoot systems.

Like a male insect following a pheromone trail produced by a receptive female insect, cytokinin follows the increasingly stronger gradient of auxin directly to the shoot tips responsible for the auxin's production. Left out of this pathway are the numerous lateral buds, especially those near the end of the branch. Without receiving the spring wake-up call from cytokinin, these lateral buds become dormant. Although they are no longer visible at the surface, each year the dormant buds move outward with the vascular cambium so that they remain close to the surface. Should something happen to disrupt the auxin-cytokinin pathway, then they may emerge and grow into branches, setting up their own auxin-cytokinin pathways with the root system.

It's also important to recognize that there are specific enzymes located at the shoot and root tips to destroy the arriving hormones after they have had their effect. These hormone-destroying enzymes are produced in the same tissue near the shoot and root tips. In the root tips, an enzyme is produced that will destroy auxin, just as in the shoot tips, an enzyme is made to destroy cytokinin. Should these enzymes not perform their tasks, the concentration of hormones will increase and cause a different response in the receptive tissues.

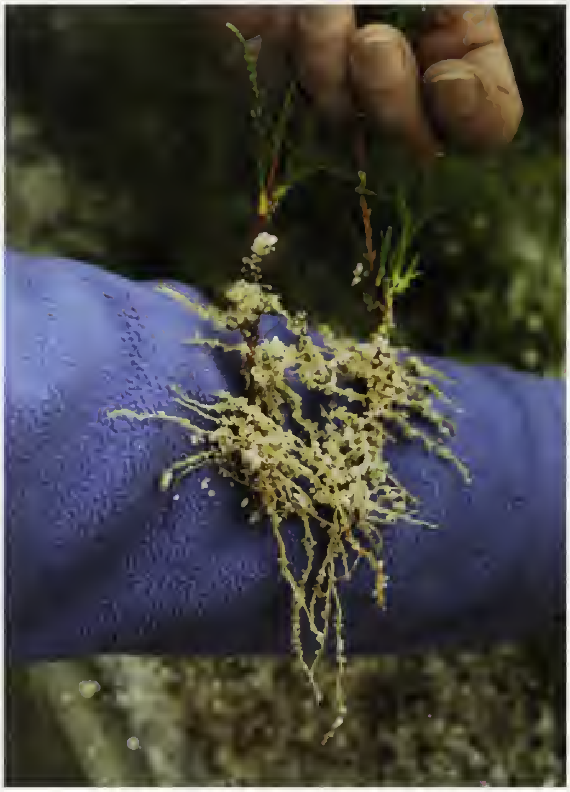
Common Tree Care Practices and the Impact of Hormone Pathways

Knowing that plants have internal mechanisms helping them with an ever-changing environment should make us pause and attempt to understand what is happening in the plant before beginning to actively "care" for the plant. Sometimes our efforts at achieving short term goals (e.g., darker green foliage, more growth, controlled shape) may be aggravating the tree's ability to achieve optimal health. Trees' hormone pathways are involved in the arboricultural practices described below:

Transplanting

Regardless of how carefully balled-and-burlapped or container-grown trees are transported and installed, some roots will be damaged and die. The roots that are particularly susceptible to damage are the very fine root tips. And it is these same roots that are to produce cytokinin and transport it up to the shoot tips to stimulate elongation of branches. This is why newly transplanted trees are so slow at developing significant shoot growth during

NANCY ROSE



Auxin accumulates at the base of stem cuttings, stimulating root initiation. Exogenous auxins, in the form of rooting powders or dips, are often applied to the bases of woody plant stem cuttings before sticking in propagation beds (rooted *Microbiota decussata* cuttings seen here).

the first year or two after transplanting. The loss of the root tips also means the loss of the ability to produce the auxin-destroying enzymes. As a result, the auxin concentration increases until the surrounding tissue responds by generating adventitious root growth. This kind of root proliferation can be observed when an African violet leaf stem is placed in water. Auxin moves down the base of the stem until it builds in concentration at the point the stem was severed from the plant, changing stem tissue into actively growing root tissue.

Fertilization

So long as there is adequate nitrogen available in the soil, tree roots will continue producing cytokinin at the appropriate times of the year in response to the establishment of the auxin pathway. However, when the nitrogen level is inadequate, the root system will suspend cytokinin production. Auxin will then be the dominant hormone directing the majority of resources to continue root growth, and a larger root system enables a search through a greater soil volume for nutrients. In nutrient poor soil, it is in the tree's best interest to invest its limited resources in root growth and not shoot growth. But if a fertilizer is applied, the root system is fooled into thinking it is in a nutrient-rich environment and the production of cytokinin increases, resulting in a larger shoot system relative to the root system. If this nutrient subsidy ceases, the tree is caught with a shoot system that cannot be sustained with the current root system.

Irrigation

Cytokinin also functions in the opening of stomata on the underside of leaves, allowing the steady movement of water from the roots to the leaves. The arch-rival of cytokinin is another root-derived hormone called abscisic acid. Abscisic acid is responsible for the closure

COURTESY OF BOB MUGAAS

When trees receive environmental subsidies, such as supplemental water from lawn irrigation systems, their internal regulatory mechanisms can be disrupted resulting in imbalanced root-to-shoot growth.

JOSEPH MURRAY

Topping, an improper pruning practice in which tree trunks and major branches are drastically cut back, results in a proliferation of weakly attached lateral shoots at the pruning points.

of the stomata when there is not enough soil moisture to perform photosynthesis. As long as the fine roots are in contact with soil and able to absorb water, cytokinin is being produced and traveling to the leaves to keep the stomata open. Should the soil begin to dry and soil particles pull away from the roots, the root system will produce abscisic acid and send it to the foliage to shut the stomata. Periodic episodes of landscape irrigation disrupt this internal regulatory mechanism, possibly placing those irrigated trees at risk for more severe damage. If periodic irrigation stops (perhaps from failure of an irrigation system or institution of municipal watering bans) the trees are suddenly exposed to drought conditions made even more acute because the shoot system has developed at a faster pace than the root system.

Improper Pruning Cuts or Storm Damage

Similar to the response observed in trees following transplanting, the loss of shoot (branch) tips will also disrupt the auxin-cytokinin pathway. Should the shoot tips be removed, the timely production of auxin and its transport to the roots will not occur in the spring. This means the cytokinin produced in the roots will not know where to travel to stimulate the growth at the end of the branch. The concentration of cytokinin will increase at the point where the branch broke or was cut because the tissue responsible for producing the cytokinin-destroying enzymes is gone. As a result, cytokinin will spread through this new truncated terminal end of the branch, finding and releasing the latent buds. This is why there is a proliferation of watersprouts emerging at the end of branches damaged by storms or by the ill-advised practice of topping trees.

Lessons Learned

Trees have existed for over 300 million years. The evolution of a hormone system allowed early plants to deal with a changing environment and to coordinate their parts in time and space. And for venerable trees, these hormone systems are particularly important. As caretakers of trees in urban areas, it is our duty to first understand these subtle internal mechanisms before blithely applying a treatment that we believe is in the tree's best interest.

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2009 Weather at the Arboretum

Bob Famiglietti

As in 2008, greater than normal rainfall occurred in 2009, resulting in optimum soil moisture conditions at the Arboretum. Excellent growth rates were recorded on a vast majority of our woody plants.

JANUARY was colder than normal. The minimum temperature dropped to at least 28°F on every night, a rare occurrence. Readings of -1°F were recorded on the 15th, 16th, and 17th, the low for the year. Three storms that each deposited about 6 inches of snow left a persistent snow cover on the ground. Snow total for the month was 21 inches.

FEBRUARY was mild and dry with only 7 inches of snow, six of that coming on the 3rd. The relative warmth reduced a foot of accumulated snow on the ground at the beginning of the month to all but a trace by the end of the month. February's high temperature of 60°F was reached on the 27th.

MARCH had average temperatures and produced only 10 inches of snow. A temperature of 61°F occurred twice, and the snow pack melted by mid month.

APRIL was a month of extremes. It began cool, as low temperatures dropped into the 30s for thirteen days. Our last freeze occurred on the 13th when it hit 32°F. Temperatures soared to the other extreme by the end of the month. Our first day over the 70°F mark arrived on the 24th, making it to 71°F. It reached 86°F on the 25th and 26th and then soared to 95°F on the 28th, an amazing leap from the freezing temperature barely two weeks earlier. This was the highest temperature since June 2008, and also turned out to be the high for the year. Rainfall was 4.13 inches for the month.

MAY was warm, cloudy, and dry. Even though rain was measured on fourteen days, it only totaled 2.76 inches for the month. Weather conditions for the Arboretum's annual Lilac Sunday event on May 10th were extremely windy, with gusts over 40 miles per hour. A high of 91°F was reached on the 21st, the only reading in the 90s for May.

JUNE had eighteen consecutive days with below normal temperatures (8th–25th) finishing almost 5°F below normal for the month. It was the third coldest June in 183 years of Boston weather-keeping records. Clouds were persistent and rain was measured on nineteen days with traces on four others. Precipitation was 3.99 inches for the month and there were only six days when no water was detected in our rain gauge. A frequent east wind kept us cloudy, cool, and damp. These cool, damp, early summer conditions made it an excellent year for post-transplanting establishment of new plants in the collection; little supplemental watering was needed. On the negative side, the cool, damp weather exacerbated a widespread outbreak of the late blight fungus (*Phytophthora infestans*) in the Northeast. Late blight attacks plants in the nightshade family (Solanaceae) and is the fungus that was a major factor in the Irish potato famine of the 1850s. Farmers and home gardeners in the region had to destroy tomato and potato crops to prevent the spread

Arnold Arboretum Weather Station Data • 2009

	Avg. Max. (°F)	Avg. Min. (°F)	Avg. Temp. (°F)	Max. Temp. (°F)	Min. Temp. (°F)	Precipi-tation (inches)	Snow-fall (inches)
JAN	29.8	13.9	21.8	40	-1	4.65	21.0
FEB	39.6	21.6	30.6	60	3	2.07	7.0
MAR	44.1	27.7	35.9	61	8	3.01	10.5
APR	60.1	40.1	50.1	95	30	4.13	
MAY	68.7	50.3	59.5	91	43	2.76	
JUN	71.5	55.5	63.5	83	43	3.99	
JUL	78.0	61.6	69.8	88	51	7.91	
AUG	82.2	65.2	73.7	93	55	3.40	
SEP	71.1	52.8	62.0	79	41	3.28	
OCT	58.2	41.2	49.7	73	32	5.62	
NOV	55.4	40.7	48.1	69	29	3.76	
DEC	39.4	23.7	31.6	69	9	5.27	10.5

Average Maximum Temperature .... 58.2°

Average Minimum Temperature .... 41.2°

Average Temperature .... 49.7°

Total Precipitation .... 49.85 inches

Total Snowfall......................... 49.0 inches

Warmest Temperature .... 95° on April 28

Coldest Temperature .... -1° on January 15,16, and 17

Last Frost Date .... 32° on April 13

First Frost Date........................ 32° on October 19

Growing Season .... 189 days

SUE A. PFEIFFER

A lightning strike at about 9 a.m. on July 2, 2009, destroyed this venerable Nikko fir (*Abies homolepis*) in the Arboretum's conifer collection. The explosive force threw pieces of the tree at least 180 feet away.

of late blight. The Arboretum has very limited holdings of woody plants in this family and no collections plants were affected. The damp conditions were also a factor in the appearance of fire blight (*Erwinia amylovora*), a bacterial disease, on some rose family (Rosaceae) plants in the collections. A high temperature of 83°F (lower than in April or May) was reached on the 26th.

JULY was also cloudy, cool, and wet, with 7.91 inches of rain, the sixth wettest July on record. There were fourteen days with measurable rainfall and traces on four others. Thunderstorms were frequent; on the 2nd, a lightning strike during a thunderstorm destroyed a notable 91-foot-tall, 110-year-old Nikko fir (*Abies homolepis*) in the Arboretum's conifer collection. 2.93 inches of rain fell on the 23rd, the highest one day total since December 11th, 2008. For five days it remained in the 60s and on eleven days it never made it out of the 70s. A high of 88°F was recorded on the 18th and 28th. We never reached 90°F, which is extremely rare for July. The combined June–July average temperature was the 4th coldest in Boston's recorded weather history.

AUGUST was very warm and, with only 3.4 inches of rain, our driest summer month. Measurable precipitation was recorded on only eight days. The high of 93°F was reached on the 18th. 90°F or greater was recorded on the 17th through the 19th, creating our only official heat wave of the summer.

Visitors and Arboretum staff commented on the outstanding orange-russet fall color exhibited by the dawn redwoods (*Metasequoia glyptostroboides*) near the Hunnewell Visitor Center late in the autumn of 2009.

SEPTEMBER was cool, sunny, and a bit dry. A heavy rain occurred on the 11th and 12th, but rainfall was measured on only five days for a total of 3.28 inches. Long sunny breaks occurred between rain days. No temperatures of 80°F or higher were recorded during the month.

OCTOBER was cold and wet. Our growing season ended on the 19th with a low of 32°F. This was the 21st coldest October in 138 years of Boston weather history. Precipitation was measured on fifteen days for a total of 5.62 inches. Damp conditions notwithstanding, visitors to the Arboretum enjoyed another great fall foliage display this year.

KEVIN B. SCHOFIELD

A cool October followed by unusual warmth in November triggered an abundance of premature late-autumn blooms on this Fuji cherry (*Prunus incisa* f. *serrata*) in the Bradley Rosaceous Collection. An early December snow brought an end to the spring preview.

NOVEMBER was warm and somewhat dry, ranking as the 7th warmest November on record. It was only slightly cooler than October. A high of 69°F was recorded on the 9th. A low of 29°F was recorded on the 6th and 17th. This warm weather kept containerized nursery plants at the Arboretum's Dana Greenhouse from going completely dormant, the condition needed for winter root cellar storage. Many of our containerized plants had to wait for the cold of December to drop their leaves. Though they commonly open a few blossoms during late fall warm-ups, this year some of the mature cherry (*Prunus* spp.) trees in the Bradley Rosaceous Collection appeared to be in nearly full bloom.

DECEMBER started warm, reaching a high of 69°F on the 3rd. But it then turned cold, remaining below freezing for eight straight days from the16th through the 23rd. This is just what our containerized woody plants needed to go into dormancy, and they could finally be put to bed for the winter. Almost a foot of snow fell over the weekend of the 19th and 20th.

Bob Famiglietti is a Horticultural Technologist at the Arnold Arboretum's Dana Greenhouses.

An Essay on *Naming Nature: The Clash Between Instinct and Science*

P. F. Stevens

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Carol Kaesuk Yoon. W.W. Norton & Company, 2009. 344 pages.
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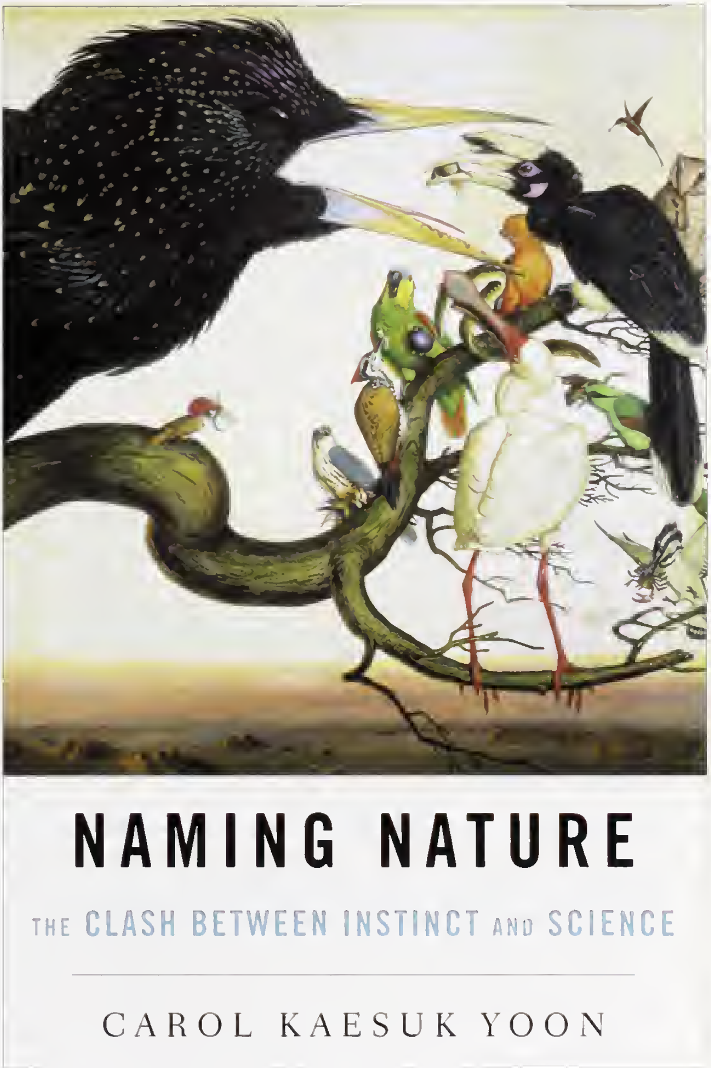

Systematics, the science of the study of relationships between organisms, has seen remarkable developments over the last fifty years. Carol Kaesuk Yoon was a graduate student in Cornell in the late 1980s, trying to elucidate the relationships between some fruit flies using the then still fairly novel technique of DNA analysis. There she witnessed some of the vitriolic debates between cladists and evolutionary biologists, two warring groups of systematists who interpreted relationships in very different ways. In fact, analysis of the molecular data that she and others were then starting to use has had profound consequences for our understanding of the living world, and our knowledge of the genealogical relationships between organisms is increasing by leaps and bounds.

Taxonomists, those who classify, have in many cases redrawn the limits of groups to better reflect these genealogical relationships. Of course, systematists had long been interested in such relationships, but they used morphological differences to establish them. As Ernst Mayr (who figures in the book's pages) noted, everybody could tell a toucan, with its remarkable beak, from a barbet. Brightly colored though the latter bird might be, barbets had much more conventional bills, and nobody in his or her right mind would put toucans and barbets in the same family. But that is exactly what the genealogical evidence suggested to some.

The resolution of this particular story is that barbets are now in four separate families, toucans remaining in their own family. For some, this is a satisfactory solution; after all, this taxonomy does take into account genealogy. But situations like these seem to make no sense intuitively—are birds to be included in reptiles, are we humans really to be placed with fish, as genealogy would suggest? Such questions led Yoon to reflect on where taxonomists and systematists were going. They seemed to have taken leave of their everyday senses as they peered myopically at bands on gels that represented DNA. On the other hand, we have always classified the living world using our

ordinary senses, and these classifications make that world real to us in a way that the new classifications do not. It is this world—she calls it the *umwelt,* the world as it is apparent to our senses, the natural order that it discloses to us—that matters to us. In the world as we perceive it, objectivity, hypothesis testing, and evolutionary change are not relevant; the whale is a fish of sorts, as are clams and maybe even coots, and humans are not apes. This is folk taxonomy, not a scholarly endeavor but a hard-wired and ageless tradition that was co-opted by Linnaeus and hijacked by molecular systematists.

In the book, we then embark on a fascinating tour. Linnaeus's Herculean labors in classifying the world are explained in detail, "capturing," as he did, "the essential vision of the living world ... the vision of the human umwelt" (p. 50). A brief discussion on Darwin's barnacles ends with the conclusion that all his brilliant evolutionary inspirations would cripple taxonomy—a wall was being erected between the scientist and the living world. Indeed, despite the title of his book, *On the Origin of Species ...*, arguments about what a species really was were not settled by Darwin, nor later by Mayr, who thought that because he and New Guinea tribesmen could recognize the same species of birds this made species objectively real. This observation simply made James Watson wonder why Harvard faculty were needed to name things if they did no better than New Guineans.

The classifications of plants and animals all over the world show remarkable cross-cultural similarities, down to the numbers of different things that are included in any one classification—which turns out to be similar to the number of genera that some of Yoon's informants, professional taxonomists, could remember; around 600 is the upper limit. Similar numerical regularities apply to species; few genera have more than seven species. Indeed, there are general memory rules here, as George Miller noted in his classical paper, "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information." The great taxonomist George Bentham was aware of such limits as he wrote *Genera plantarum* with Joseph Dalton Hooker in the later nineteenth century. Yoon notes that it has been shown that names of fish sound like names of, well, fish, rather than of birds or some other animal. This is the classificatory umwelt that we have left behind. She also describes some remarkable people with brains damaged in particular ways who could no longer classify organisms.

Returning to academia, the arguments between the three main group of systematists—cladists, pheneticists, and evolutionary systematists—are described very perceptively. Yoon sees that the cladistic approach—recognizing relationships because of shared unique characters—has allowed us to start assembling a tree of life that shows us surprising things about the world. However, this is not the world of our senses, since the living world has been excluded. What is the mere mortal to do?

Indeed, there is a tension here. Yoon suggests that classifications were developed specifically for communicating about organisms. However, classifications extend to every part of our world, living or not. We classify items in a supermarket just as effectively as we do organisms. We may have lost contact with life, but we have not lost the ability to classify. Indeed, classification is not so much part of an umwelt that has to do with life in particular but something we do to everything. The binomial, a noun-adjective combination that Linnaeus used, is simply two words we use to describe groups of things, whatever they may be. A red cart and a red oak have the same grammatical and cognitive structure, but one refers to things and the other to plants.

In the end, Yoon suggests that we name organisms as we please. There is no one classification, but each classification is a variation on a universal theme; we must reclaim our own umwelts. And herein is food for thought. What is our umwelt? She acknowledges that all individual classificatory systems may be different, but of course the great advance made almost inadvertently by Linnaeus was a way of communicating. A common language, a common classification, is always essential. And whether our umwelt tells us anything in particular or stable is debatable, certainly, our attitudes to the environment have changed dramatically over the last few hundreds of years, and our prelapsarian ideas might not seem very satisfactory to us now. Eyewitness accounts may well be decidedly less than accurate, as any trial

***Carolus Linnaeus*, a larger-than-life bronze statue of the "father of modern taxonomy" by Robert Berks, in the Heritage Garden at the Chicago Botanic Garden.**

lawyer or judge will know. Thus, to oppose the new classifications we are developing with an umwelt-based classification that reflects an understanding of the phenomenal (= real) world, seems a mistake.

I have been through the biological battles that Yoon describes, and am also a maker, user, and teacher of classifications. There is much more than just DNA sequencing and changing names going on. We are learning much more about the living world and in such a way that it makes us wonder and understand in a way that was impossible before. When I take beginning biology students around the campus and talk about bacteria in the nodules in the pea family, and the bacteria-that-were that pervade cells as mitochondria and chloroplasts (all features that also reflect the new classifications) students clearly understand the world in a very different way. A classification based on umwelt and instinct would be a sorry substitute.

The reader will learn a great deal from this book, which is well and clearly written (although the asparagus has never been included in the orchid family, p. 235). The issues that it raises are ongoing. Even aside from the "debate" over global warming and evolution, scientists sometimes forget the limits of their world: their truth is not necessarily broadly self-evident. Readers of Yoon's book will surely enjoy *Trying Leviathan:...* by D. Graham Burnett, which raises similar issues, but in a historical context, as the subtitle of that book explains: *The Nineteenth-Century New York Court Case That Put the Whale on Trial and Challenged the Order of Nature.* The ultimate question is surely why we need alternative classifications and what are the situations in which they help—and what are those in which they are a hindrance. Whether the umwelt, whatever it is (and the word is overused in this review as it is in the book itself), will help us as we think about this, I do not know, although I doubt it. And we do need to think about what is, not what seems—and I say this fully aware of the difficulties surrounding that most simple of words, "is".

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The Sand Pear—*Pyrus pyrifolia*

Peter Del Tredici

In more than thirty years at the Arnold Arboretum, I have observed many trees in our collections. Some have not lived up to expectations, but others have proven themselves over time. One such tree is the specimen of sand pear (*Pyrus pyrifolia*, accession 7272-C) growing at the back edge of the open meadow below the summit of Bussey Hill, which I consider to be the most beautiful flowering tree in the Arboretum.

This tree comes into flower in late April or early May, depending on the weather, and at its peak bloom it shines like a beacon in the early spring landscape. When first glimpsed from Bussey Hill Road, against a backdrop of tall white pines, it looks like a giant white cloud—an effect that is intensified because no leaves compete with the floral display. The flowers are pure white with crimson anthers, 3 to 3.5 centimeters (1.2 to 1.4 inches) in diameter, and are borne in rounded clusters on slender stalks. In bloom, the tree can be easily spotted from the top of Peters Hill, some 800 meters (2,600 feet) away as the crow flies. It stays in flower for up to a full week, holding up well through all kinds of inclement early spring weather.

In fall, the tree's glossy, dark green leaves turn beautiful shades of orange and red. Its hard, round fruits are 3 to 4 centimeters (1.2 to 1.6 inches) in diameter, brown, and covered with pale dots. The fruit has an extremely gritty texture (hence its common name—sand pear) and a puckery aftertaste when bitten into. It's hard to imagine how the delectable Chinese and Japanese "apple-pears" in the supermarket were derived from this astringent ancestor.

The magnificent sand pear on Bussey Hill stands 16.9 meters (55.4 feet) tall with a spread of 25.7 meters (84.3 feet) and a trunk DBH (diameter at breast height) of 79 centimeters (31.1 inches). Remarkably, it seems never to have suffered any major snow, ice, or wind damage—an unexpected observation given its age (101 years) and the exposure of the site where it is growing. Such structural integrity provides a striking contrast to the widely planted but notoriously weak 'Bradford' Callery pear (*Pyrus calleryana* 'Bradford'), which shows an all too predictable tendency to split apart in severe storms after about age 20. Were it not for its relatively large, messy fruits, our streets might well have been planted with sand pears instead of Callery pears.

The Arboretum's beacon tree was grown from seed collected by E. H. Wilson in the fall of 1907, somewhere in the mountains surrounding the city of Ichang in Hupeh (now Hubei) Province. When Wilson collected the seed he did not give the tree a species name, but noted that the Chinese called it "tang li tzu." At the time, sand pears were classified as *Pyrus sinensis*, a name which was used mainly to describe cultivated plants with large, edible fruits. Back at the Arboretum, Alfred Rehder decided that Wilson's tree was the wild ancestor of these cultivated trees and, in 1915, proposed the name *Pyrus serotina* for Wilson's specimens. Taxonomy is ever changeable, though, and in 1926 the Japanese botanist Nakai reduced Rehder's name to synonymy with *Pyrus pyrifolia*—the name the species now bears.

Wilson's sand pear seeds arrived at the Arboretum in April 1908 and germinated in the spring of 1909. Sometime prior to 1918, at least three of the seedlings were planted on the grounds. Remarkably, all three are still alive today—a testament to the toughness and tenacity of the species. Specimen 7272-C is the finest of the three, and it will, I hope, remain a shining spring beacon for Arboretum visitors for many years to come.

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